#8

PATENT
Attorney Docket No. 440490

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Appln. of:

FENDYA et al.

Application No. 09/890,355

Filed: March 28, 2002

Art Unit: 2684

Examiner: Aminzay, S.

PETITION PURSUANT TO 37 CFR 1.182

Commissioner for Patents
U.S. Patent and Trademark Office
220 20th Street S. Customer Window, Mail Stop PCT
Attention: PCT Legal
Crystal Plaza Two, Lobby, Room 1B03
Arlington, VA 22202

Dear Sir:

The above-referenced patent application is the §371 National Phase application of International Application No. PCT/US00/02071. However, the application which has been placed in the file and examined by the U.S. Patent and Trademark Office is International Application No. PCT/US00/02701. Applicants, through their attorney, petition, pursuant to 37 CFR 1.182, for the application corresponding to International Application No. PCT/US00/02071 to be placed in the file and for examination of the correct application.

The Transmittal Letter submitted to the United States Designated/Elected Office Concerning a Filing under 35 USC 371 on July 30, 2001, which was an express request to begin national examination procedures for International Application No. PCT/US00/02071, incorrectly identified the International Application No. as PCT/US00/02701. The International Search Report, International Preliminary Examination Report, Application Data Sheet, and Postcard submitted with the Transmittal Letter, each correctly referred to PCT/US00/02071 and the correct specification, claims and drawings for International Application No. PCT/US00/02071 were also submitted. A Combined Declaration and Power of Attorney submitted in response to the Notification of Missing Requirements also correctly identified the International Application. On or about May 7, 2002, more than two years prior to receiving the first Official Action, Applicants representative discovered the error and contacted the U.S. Patent and Trademark Office employee, Patricia Booker, believed to have most recently handled the case (a Notice of Acceptance of Application signed by Ms. Booker having been received on April 26, 2002). Pursuant to Ms. Booker's instructions, a corrected transmittal letter was sent via facsimile to Ms.

Booker's attention on May 7, 2002. No further correspondence was received from the U.S. Patent and Trademark Office until an Official Action was received on July 9, 2004, containing a detailed action on the wrong application.

As proof of the foregoing facts, attached are copies of the originally submitted Application Data Sheet, International Search Report, International Preliminary Examination Report, the specification, claims, and drawings, date stamped postcard, the Combined Declaration and Power of Attorney, and the corrected transmittal letter and associated facsimile cover sheet.

Petitioners request that the correct documents be placed in the file and that the patent application be forwarded to the appropriate technology center for examination.

The fee of $130, in effect at the time of filing of this Petition, required pursuant to 37 CFR 17(h) should be charged to Deposit Account No. 12-1216. A duplicate copy of this Petition is attached.

Respectfully submitted,

Shannon Schemel

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FACSIMILE COVER SHEET

DATE: MAY 7, 2002

NUMBER OF PAGES (INCLUDING THIS TRANSMITTAL COVER SHEET): 3

OUR REFERENCE: 440490

FROM: SHANNON D. SCHEMEL
REGISTRATION NO. 47,926

EXTENSION NO.: 224

TO: **ATTN: PAT BOOKER**
UNITED STATES PATENT AND TRADEMARK OFFICE
WASHINGTON, D.C.

TELEPHONE NUMBER: 703-305-3738
FACSIMILE NUMBER: 703-305-3230

IN RE APPLN. OF: FENDYA ET AL.
SERIAL NO. 09/890,355
FOR: SEPARATION DEVICES AND PROCESSES
INTERNATIONAL APPLICATION NO. PCT/US00/02071
INTERNATIONAL FILING DATE: 1/31/2000

MESSAGE: **APPLICATION NUMBER 09/890,355 IS A 371 OF PCT/US00/02071. ATTACHED IS A CORRECTED TRANSMITTAL LETTER.**

U.S. DEPARTMENT OF COMMERCE
PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 USC 371

ATTORNEY DOCKET NO.
40490/PALL

U.S. APPLICATION NO.

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/US00/02071	January 31, 2000	January 29, 1999

TITLE OF INVENTION
SEPARATION DEVICES AND PROCESSES

APPLICANT(S) FOR DO/EO/US
PALL CORPORATION

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 USC 371.

2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 USC 371.

3. ☒ This is an express request to begin national examination procedures (35 USC 371(f)).

4. ☐ The US has been elected by the expiration of 19 months from the priority date (PCT Article 31).

5. ☒ A copy of the International Application as filed (35 USC 371(c)(2))
   a. ☐ is attached hereto (required only if not communicated by the International Bureau).
   b. ☒ has been communicated by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).

6. ☐ An English language translation of the International Application as filed (35 USC 371(c)(2)).

7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 USC 371(c)(3))
   a. ☐ are attached hereto (required only if not communicated by the International Bureau).
   b. ☐ have been communicated by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.

8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 USC 371(c)(3)).

9. ☐ An oath or declaration of the inventor(s) (35 USC 371(c)(4)).

10. ☐ An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 USC 371(c)(5)).

11. Nucleotide and/or Amino Acid Sequence Submission
   a. ☐ Computer Readable Form (CRF)
   b. Specification Sequence Listing on:
      i. ☐ CD-ROM or CD-R (2 copies); or
      ii. ☐ Paper Copy
   c. ☐ Statement verifying identity of above copies

Items 12 to 19 below concern other document(s) or information included:

12. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
   ☐ Form PTO-1449
   ☐ Copies of Listed Documents

13. ☐ An assignment for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.

14. ☐ A FIRST preliminary amendment.
   ☐ A SECOND or SUBSEQUENT preliminary amendment.

15. ☐ A substitute specification.

16. ☐ A change of power of attorney and/or address letter.

17. ☒ Application Data Sheet Under 37 CFR 1.76

18. ☒ Return Receipt Postcard

19. ☒ Other items or information: Copy of application as filed and corrected drawings; International Search Report (Forms PCT/ISA/220 and PCT/ISA/210); and International Preliminary Examination Report (Forms PCT/IPEA/416 and PCT/IPEA/409)

U.S. APPLICATION NO.	INTERNATIONAL APPLICATION NO.	TORNEY DOCKET NO.
	PCT/US00/02701	440490/PALL

20. ☒ The following fees are submitted:	CALCULATIONS	PTO USE ONLY
Basic National Fee (37 CFR 1.492(a)(1)-(5)):		
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO $1,000.00		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO ..... $ 860.00		
International preliminary examination fee (37 CFR 1.482) paid to USPTO, but international search fee (37 CFR 1.445(a)(2))paid to USPTO ..... $ 710.00		
International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4)..... $ 690.00		
International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1) to (4) ..... $ 100.00		
ENTER APPROPRIATE BASIC FEE AMOUNT=	$690.00	
Surcharge of $130.00 for furnishing the National fee or oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date	$	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total Claims	7 -20=		x $ 18.00	$	
Independent Claims	7 - 3 =	4	x $ 80.00	$320.00	
☐ Multiple Dependent Claim(s) (if applicable)			+$270.00	$	

TOTAL OF ABOVE CALCULATIONS=	$1010.00	
☐ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.	$	
SUBTOTAL=	$	
Processing fee of **$130.00** for furnishing English Translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date.	$	
TOTAL NATIONAL FEE=	$1010.00	
Fee for recording the enclosed assignment. The assignment must be accompanied by an appropriate cover sheet. **$40.00** per property +	$	
TOTAL FEE ENCLOSED=	$1010.00	
	Amount to be: refunded	$
	charged:	$

a. ☒ A check in the amount of $1010.00 to cover the above fee is enclosed.

b. ☐ Please charge Deposit Account No. 12-1216 in the amount of $ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 12-1216. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

23548

PATENT TRADEMARK OFFICE

John M. Belz, Registration No. 30,359
One of the Attorneys for Applicant(s)

7 May 2002
Date

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JMB/etp

The Patent Office acknowledges, and has stamped hereon, the date of the receipt of the items checked below:

Docket No.: 440490/PALL 09/890355
Inventor(s): FENDYA ET AL
Title: SEPARATION DEVICES AND PROCESSES

☒ Transmittal Letter for a (2 pages; w/duplicate copy)
☐ Rule 53(b) appln ☐ Rule 53(c) provisional appln
☒ §371 national phase appln of PCT/US00/02071

No. Pages of Spec.: 45+Abstract
No. Pages of Claims: 3
No. Sheets of Drawings: 11
☒ Application Data Sheet
☒ Return Receipt Postcard
Fee $1010.00
☒ Check ☐ Charged to Deposit Account
☐ Declaration
☐ Associate Power of Attorney
☐ Assignment & Fee
☐ Preliminary Amendment
☐ Priority Document
☐ Information Disclosure Statement
☐ Small Entity Statement(s) ( )
☐ PTO-1449 (pages) ☐ & documents
☒ International Search Report (Forms PCT/ISA/210 and PCT/ISA/220
☒ International Preliminary Examination Report (Forms PCT/IPEA/409 and PCT/IPEA/416)

SEPARATION DEVICES AND PROCESSES

This application claims priority of United States Application No. 60/117,972, which is incorporated by reference.

Field of the Invention

This invention relates to the separation of particles and/or fluid from a mixture including the particles suspended in the fluid. For example, it relates to the purification or clarification of a fluid by removing particles from the fluid; to the segregation of particles by removing one or more types, sizes, or species of particles from the fluid; and to the concentration of one or more types, sizes, or species of particles by the removal of a portion of the fluid.

The invention is useful for a wide variety of particles and fluids in microfiltration, ultrafiltration, nanofiltration, reverse osmosis, and shear separation as described, for example, in International Publication No. WO98/09717. For example, the particles could be macro-molecules, micelles, liposomes, or bacteria suspended in a fluid, such as a biological fluid, as would be common in biotechnical, cosmetic, and pharmaceutical processes. As another example, the particles could be metal debris suspended in oil as would result from various metal machining operations. As further examples, the particles could be paper fibers suspended in water as would result from various portions of paper making processes or oil droplets suspended in water as occurs in cleanup of

oily wastes.

Background of the Invention

One type of conventional separation is "dead-end" filtration. In dead-end filtration, a fluid containing suspended particles is directed along a flow path where it is forced to flow through a porous filter medium, such as a porous membrane. The primary characteristic of the membrane is its pore size distribution. Those particles which are relatively small compared to the pore size distribution may be transmitted through the membrane with the fluid while those particles which are relatively large compared to the pore size distribution may be retained on the surface or within the pores of the membrane, thus effecting a separation of the particles suspended in the fluid. The size above which most particles are retained and below which most particles are transmitted is referred to as the cut-off size of the membrane.

As particles accumulate within or on the surface of the porous medium (i.e., a process known as fouling), the effective sizes of the membrane pores decreases. This results in an increase in the power required to maintain the flow through the membrane and a shift in the cut-off size. Both of these results of fouling have important consequences for separation processes. The increase in power required increases the cost of the separation process and the shift in cut-off size affects the function of the separation processes.

In many separation applications, especially those involving biological fluids, the shift in cut-off size renders the use of conventional dead-end filters ineffective.

Another type of conventional separation is "tangential" or "cross-flow" separation. Cross-flow separation can alleviate, and in some cases eliminate, the detrimental effects of fouling in dead-end filtration. In cross-flow separation, the mixture of particles and fluid is driven through a passage or channel, the walls of which include a porous medium, such as a porous membrane. One portion of the mixture, (i.e., the retentate or concentrate) passes tangentially along the membrane and exits the device without passing through the membrane while the remaining portion of the mixture (i.e., the permeate or filtrate) passes through the membrane to effect the separation. The purpose of forcing a portion of the flow to be parallel or tangential to the membrane surface is to generate a layer of high shear near the membrane surface which tends by various mechanisms to reduce the fouling that would occur in dead end filtration.

Although effective, conventional cross-flow separation is not without serious problems. One problem is non-uniform distribution of the flow over the membrane surface, especially with cross-flow devices that are made up of flat sheets of membranes with wide rectangular channels for the feed flow. Another problem, which affects both tubular and rectangular channel forms of conventional

cross-flow devices, is that the shear rates generated in conventional cross-flow devices are frequently not large enough to prevent the development of a layer of highly concentrated suspended particles on the feed (or upstream) side of the membrane. This layer of concentrated particles is referred to as a gel layer and the phenomenon by which it is created is referred to as concentration polarization. The gel layer acts as a filter with much smaller pores than the membrane. If particles of a certain size are retained by the membrane, much smaller particles will be retained by the gel layer. As a result, many conventional cross flow devices and processes are unable to effect separations of particles that differ in size by less than an order of magnitude.

The gel layer may be significantly reduced or eliminated by increasing the shear rate. Shear rates, which in conventional cross-flow devices may be on the order of 10^4 inverse seconds, may be increased by increasing the pressure gradient between the feed inlet and the retentate outlet. However, it has generally been considered impractical to substantially increase the shear rate because a large pressure gradient from the feed inlet to the retentate outlet causes a large permeate flux at the inlet end of the device and a relatively small permeate flux at the retentate end. The large flux near the inlet counteracts the shear and leads to concentration polarization, while the small flux at the outlet reduces throughput and efficient use of the membrane. Restricting the

permeate flow by means of a control valve downstream of the permeate outlet does not alleviate this problem. Restricting the permeate flow with a valve changes the pressure on the permeate side of the membrane uniformly but does not significantly change the large pressure gradient along the upstream side of the membrane. Consequently, the difference between the permeate flux near the inlet and the permeate flux near the outlet remains. It can even happen that the permeate flow is restricted so much that although the flux at the inlet end is reduced enough to avoid concentration polarization, the permeate flux at the outlet end is reversed and flows from the permeate side to the retentate side of the membrane. This phenomenon is known as Starling flow.

The gel layer may also be significantly reduced or eliminated by keeping the permeate flux below a critical value that depends on factors such as the shear rate, the membrane properties, and the suspension being separated. Control of permeate flux may be accomplished by control of transmembrane pressure (TMP), where TMP may be defined as the difference between the pressure at a location on the upstream side of the membrane and the pressure at the corresponding point on the downstream, or permeate, side of the membrane. The flux through the membrane tends to increase with TMP. However, the rate of fouling increases with flux; so the relationship between permeate flux and TMP is not generally linear. In conventional cross-flow devices, as the TMP is increased, the

permeate flux increases, but the rate of increase approaches zero as the permeate flux asymptotically approaches a maximum, regardless of how much the TMP is increased.

A well known approach to controlling TMP is to re-circulate the permeate fluid through the permeate passages at a fast enough flow rate that the change in pressure within the permeate passages from the portion near the inlet end of the device to the portion near the retentate end of the device is the same as the corresponding pressure drop along the upstream side of the membrane. This approach, which is described in USP 4,105,547, requires the added expense of a pump to drive the re-circulating permeate flow. Another difficulty with re-circulating permeate to maintain uniform TMP is that generally the permeate volume flow rate is so much smaller than the retentate flow rate that the re-circulation rate must be very large, or the cross sectional area of the permeate passages must be excessively small, to establish a pressure drop equal to that on the retentate side.

Summary of the Invention

The present invention provides many improved separation devices and processes. For example, according to one aspect of the invention, a separation device comprises a feed channel through which feed fluid flows. The feed channel includes a shear region having a length in the direction of feed fluid flow. The separation

device also comprises no than one permeate channel operatively associated with the shear region of the feed channel. The permeate passage extends generally perpendicular to the direction of feed fluid flow. The permeate passage has a width in the direction of feed fluid flow which is less than the length of the shear region of the feed channel. The separation device further comprises a porous medium positioned between the shear region of the feed channel and the permeate passages.

According to another aspect of the invention, a separation device comprises a feed channel through which feed fluid flows. The feed channel includes a shear region. The separation device also includes no more than one permeate passage operatively associated with the shear region of the feed channel. The permeate passage extends generally perpendicular to the direction of feed fluid flow and has a width in the direction of feed fluid flow less than about 20 mm. The separation device further comprises a porous medium positioned between the shear region of the feed channel and the permeate passage.

According to another aspect of the invention, a separation device comprises a feed channel, two or more permeate passages, and a porous medium. The feed channel includes a shear region and the permeate passages are operatively associated with the shear region of the feed channel. Further, the permeate passages include at least first and second permeate passages which are

isolated from one another. The porous medium is positioned between the shear region of the feed channel and the permeate passages.

According to another aspect of the invention, a separation device comprises a feed channel through which feed fluid flows and two or more permeate passages through which permeate flows. The feed channel includes a shear region and the permeate passages are operatively associated with the shear region of the feed channel. The separation device further comprises at least first and second flow/pressure control devices. Each of the first and second control devices are arranged to control permeate one permeate and/or pressure within one permeate passage or group of permeate passages independently of the permeate flow and/or pressure within another permeate passage or group of permeate passages. The separation device further includes a porous medium positioned between the shear region of the feed chamber and the permeate passages.

According to another aspect of the invention, a separation process comprises generating a shear layer in a feed fluid and passing permeate from the shear layer into a first permeate passage. The separation process further comprises passing permeate from the shear layer into a second permeate passage isolated from the first permeate passage.

According to another aspect of the invention, a separation

process comprises generating a shear layer in a feed fluid and passing permeate from the shear layer into first and second permeate passages. The separation process further comprises controlling permeate flow and/or pressure in the first and second permeate passages independently of one another.

According to another aspect of the invention, a separation process comprises generating a shear layer in a shear region at a porous medium. The separation process further comprises independently controlling the transmembrane pressure (TMP) incrementally along the length of the shear region.

Separation devices and processes embodying one or more of the aspects of the present invention provide many advantages over conventional devices and processes. For example, many of the embodiments operate at much higher shear rates than some of the conventional devices and processes, e.g., shear rates higher by an order of magnitude or more. Consequently, these embodiments can operate for an extended period of time without significantly fouling the porous medium and without the formation of a gel layer adjacent to the porous medium. Further, many of the embodiments provide for control of the permeate flow and/or pressure, allowing highly efficient use of the entire porous medium and enhanced permeate throughput even at the higher shear rates.

Description of the Figures

Figure 1 is a schematic representation of a cross flow device.

Figure 2 is a cross section of the cross flow device of Figure 1.

Figure 3 is a cross section of another cross flow device.

Figure 4 is an enlarged view of a portion of the cross flow device of Figure 3.

Figure 5 is a graph of flux vs. time.

Figure 6 is a graph of pressure vs. time.

Figure 7 is a partial cut-away view of another cross flow device.

Figure 8 is a cross section of the cross flow device of Figure 7.

Figure 9 is an end view of the separation pack of the cross flow device of Figure 7 prior to wrapping the separation leaves around the spool.

Figure 10 is an oblique view of a separation leaf of the cross flow device of Figure 7.

Figure 11 is a sectional oblique view of an outer portion of the separation leaf of Figure 10.

Figure 12 is a sectional oblique view of an inner portion of the separation leaf of Figure 10.

Figure 13 is a sectional oblique view of the inner portion of the separation leaf of Figure 12 showing the permeate grid and the

inner header disassembled.

Figures 14A-14C are partial front views showing spacers between porous media.

Figures 15 and 16 are oblique views of additional cross flow devices.

Figures 17A-17D are partial oblique views showing an end of a separation leaf of the cross flow devices of Figures 15 and 16 in assembled and disassembled states.

Figure 18 is an oblique view of an assembly of cross flow devices.

Figure 19 is a schematic representation of another cross flow device.

Figure 20 is a top view of the stack of filter elements of the cross flow device of Figure 19.

Figure 21 is a partial cross section of the stack of filter elements of Figure 20.

Description of Embodiments of the Invention

In accordance with one aspect, the invention provides cross-flow devices and processes which generate a layer of high shear in a shear region between a feed inlet and a retentate outlet, thereby operating at shear rates large enough to prevent the formation of a gel layer, and which control permeate flow or pressure, and therefore TMP, in the shear region along the length of the porous

medium without recirculating permeate. Feed fluid may be directed through the shear region in a single pass made or recirculated in a multipass mode. The porous medium may be any separation medium suitable for the type of fluid being processed and the desired type of separation, e.g., microfiltration, ultrafiltration, nanofiltration, reverse osmosis, or shear separation. The porous medium may comprise a porous metal, ceramic, glass, or polymeric medium. The porous medium may be in the form of a porous sheet or tube, a woven or non-woven fibrous web, a fibrous mass, or a porous or semipermeable membrane. Preferred porous media include polymeric membranes, a fine woven metal mesh, and a porous metal such as porous gold.

Various cross flow devices and processes embodying the invention are capable of generating large shear rates, e.g., in excess of 500,000 inverse seconds or even in excess of 700,000 inverse seconds, by driving large feed flows in the shear region through small openings such as narrow gaps having porous surfaces or small diameter tubes having porous walls. Driving large flow rates through narrow gaps generates a large pressure drop in the shear region between the feed inlet and the retentate outlet of the device, and the permeate flow or pressure, and therefore TMP, is preferably controlled in the presence of such large feed inlet to retentate outlet pressure differentials. In accordance with one aspect of the invention, the permeate path in the vicinity of the

shear region is divided into at least one and preferably a plurality of independent permeate flow passages. The passages are preferably oriented generally perpendicular to the feed flow direction. The permeate flow passages (or groups of permeate flow passages) are preferably isolated from one another to allow an independent permeate flow or pressure within each permeate flow passage (or group), thereby incrementally controlling TMP along the entire length of the shear region. The permeate flow or pressure in the permeate passages is preferably controlled such that the TMP for each permeate passage (or group) corresponds to a desired relationship of the TMP along the length of the shear region. For example, it may be desirable to have the TMP constant along the length of the shear region, i.e., a uniform TMP, or it may be desirable to have the TMP at one or more locations along the shear region higher or lower than at other locations, i.e., a non-uniform TMP.

A sketch of the flow paths for one example of a cross flow device 10 embodying the invention is shown in Figures 1 and 2. In this device 10 two generally planar, narrow gap, feed (or retentate) channels 12 are shown. Alternatively, one or more than two feed channels can be used. For example, cross flow devices with more feed channels can be constructed by repeating the structure shown in the vertical direction. Each channel 12 includes a shear region 14 in the gap between a feed inlet 16 and a retentate outlet 18

where a layer of high shear is generated as the fluid flows from the feed inlet 16 to the retentate outlet 18, as shown in Figure 2. Each narrow gap preferably has a height, more preferably a uniform height, in the range from about 0.07 mm to about 1.30 mm. Each feed channel 12 also preferably includes an upper porous medium 20 and a lower porous medium 20, such as a porous membrane, each of which defines a porous surface in the shear region 14 of the feed channel 12 and separates the shear region 14 of the feed channel 12 from the permeate passages 22, as shown in Figure 2. Alternatively, only a single porous medium may be disposed in each feed channel. A feed manifold may be arranged to conduct fluid from a single feed pipe to the multiple feed channels. A retentate manifold may be arranged to conduct fluid away from the multiple retentate outlets to a single retentate pipe.

Fluid that passes from the feed channel 12 through the membranes 20 enters one of the many permeate passages 22, the permeate passages 22 being preferably oriented perpendicular to the direction of feed flow. Each permeate passage 22 is preferably dimensioned such that the span across (i.e., the width of) one permeate passage 22 in the feed flow direction encompasses a small segment of the length of the shear region 14 of the feed channel 12, for example, less than about 75%, preferably less than 50%, more preferably less than 25%, and even more preferably less than 15% or less than 10%. Consequently, there is only a

relatively small pressure differential along the feed channel 12 from the upstream or leading edge to the downstream or trailing edge of each permeate passage 22. Although the widths of the permeate passages 22 may vary one from another, the widths are preferably uniform and are preferably in the range from about 2 mm or less to about 15 mm or more. The width of each permeate passage 22 may be dimensioned such that the difference in TMP from the leading edge to the trailing edge of the permeate passage 22 is preferably on the order of about 10 psi or less, more preferably on the order of about 1 psi.

Permeate flow or pressure my be controlled in a variety of ways. For example, permeate flow from the permeate passages may be directed to a set of flow and/or pressure control devices. The flow and/or pressure control devices may be configured in any suitable manner, including, for example, as flow restrictors or valves. Flow restrictors, such as fixed or variable orifices or capillaries, may be preferable where less precise control is suitable. Preferably, the flow/pressure control devices comprise a set of flow control valves 24, as shown in Figure 1. Each permeate passage 22 may be connected to a different flow control valve 24. However, it is preferable to group permeate passages 22a, 22b...22i, 22j which are adjacent to similar feed pressures with a common flow control valve 24a...24j. In the illustrated embodiment, all permeate passages 22a, 22b...22i, 22j taking permeate from the same

distance downstream of the feed inlet 16 direct their flow to the same control valve 24a...24j. The number of control valves 24 is then equal to the number of permeate passages 22 into which the permeate flow from a single porous membrane 20 is divided. (To simplify the drawing, only the initial and final flow control valves 24a, 24j are shown in Figure 1.) Alternatively, a permeate passage and one or more downstream permeate passages, e.g., two adjacent permeate passages 22a, 22b, may be coupled to the same control valve. The output of each flow control valve 24a...24j may be supplied to a common permeate manifold 26.

Each flow control valve 24may be adjusted (either manually or by means of a control system which may be coupled to the flow/pressure control devices and which may or may not use feedback as part of the control mechanism) to maintain a desired permeate flow or pressure within a permeate passage 22 and, therefore, a desired TMP across the membrane 20 associated with that permeate passage 22. Different permeate flows or permeate pressures may be provided for different permeate passages 22. The control valves 10 are preferably adjusted to provide a permeate flow or pressure within each permeate passage 22 which generates a substantially uniform TMP along the entire length of the shear region 14. However, the control valves 10 may be adjusted to provide a non-uniform TMP along the length of the shear region 14. Further, whether the TMP is initially uniform or non-uniform, the

control valves 10 may be adjusted over time to vary the permeate flow or pressure within the permeate passages 22, for example, to compensate for any changes in the permeability of the membrane.

One advantage a cross-flow device embodying this invention has over conventional cross-flow devices is that it allows much higher shear rates to be generated while maintaining reliable control of the permeate flow/pressure or TMP. This allows separations to be accomplished without the interference of a gel layer using the pore size distribution of the membrane to separate particles and/or the shear effect to separate particles independently of the membrane characteristics as described in International Publication No. WO98/09717. Because the shear rates are very large, the permeate flow rates at which these separations can be accomplished are orders of magnitude larger than can be achieved with conventional cross-flow.

Another advantage a cross-flow device embodying this invention has over conventional cross-flow devices is that it allows permeate flow to be controlled locally over the full length of the feed flow path. The spatial resolution of this local control corresponds to the widths of the permeate passages, which can be made as small as desired. The smaller the width of the permeate passages, the greater the spatial resolution but also the greater the number of flow control valves.

Another example of a cross flow device 30 embodying the

invention is shown in Figures 3 and 4. The cross flow device 30 may be arranged as part of a test setup and may include a test fixture 32 and a filter element 34.

The test fixture 32 includes a feed channel 36 extending between a feed inlet 38 and a retentate outlet 40. The feed channel 36 includes a shear region 42 in a narrow gap 44. The gap 44 preferably has a uniform and stable height between the surface of a porous membrane 46 of the filter element 34 and the fixture wall 48 opposite the membrane 46 as well as a sealed gap cross section to assure that flow readings relate directly to the pressure drop across the gap 44. The width and length of the gap may be variously dimensioned without departing from the scope of the invention. The height is preferably in the range from about 0.07 mm to about 1.30 mm. In the illustrated embodiment, the gap 44 has a length of about 17.6 mm, a width of about 40 mm, and a height of about 0.178 mm.

The test fixture 32 may be configured in a variety of ways. For example, the test fixture 32 may include an upper housing portion 50 and a lower housing portion 52 formed from a structurally rigid material such as a rigid polymer or a metal, e.g., stainless steel. The upper housing portion 50 may include the feed inlet 38 and the retentate outlet 40. The lower housing portion 52 may include a permeate outlet 54 and a seat 56 for a permeate port O-ring 58. The lower housing portion 52 also lends additional

structural integrity to the filter element 34 and aids in providing a uniform gap 44.

The filter element 34 preferable includes a support plate 60. A porous membrane support 62 is disposed on the support plate 60 and the porous membrane 46 is disposed on the membrane support 62. Both the porous membrane support 62 and the porous membrane 46 are preferably permanently affixed, e.g., solvent bonded, to the support plate 60 and preferably extend the full dimensions of the support plate 60 to assure no disruption of the flow in the gap 44. Each of the support place 60, the porous membrane support 62, and the porous membrane 46 may be fashioned from a variety of suitable materials. In the illustrated embodiment, the support plate 60 may comprise a rigid metal or polymeric material such as a polysulfone plate, the porous membrane support 62 may comprise a woven or nonwoven polymeric sheet or mesh, and the porous membrane 46 may comprise a polymeric membrane such as a nylon 66 membrane having a 35 psi K_L and a 0.152 mm thickness as available from Pall Corporation. While a porous membrane is the preferred porous medium for this embodiment, other porous media, including woven or nonwoven polymeric sheets or porous metal sheets, are also suitable.

The cross flow device 30 of the illustrated embodiment has only one permeate passage 64 associated with the shear region 42.

The permeate passage 64 preferably extends generally perpendicular to the direction of feed flow and has a relatively narrow width from the leading edge to the trailing edge compared to the length of the gap 44. For example, the wide of the permeate passage 64 may be less than about 75%, more preferably less than about 60%, of the length of the gap 44. Limiting the relative extent of the permeate passage 64 facilitates control of the permeate flow and/or pressure within the permeate passage 64. Consequently, a permeate flow/pressure control device may be omitted. The gap 44 preferably extends upstream of the leading edge of the permeate passage 64 a distance sufficient to straighten the incoming feed flow. For example, in the illustrated embodiment, the leading edge of the permeate passage 64 is about 5 mm from the gap entrance and the trailing edge of the permeate passage 64 is about 2 mm from the gap exit.

The permeate passage 64 may be formed in any suitable manner, e.g., as a continuous rectangular channel as shown in Figures 1 and 2. In the embodiment illustrated in Figures 3 and 4, the permeate passage 64 comprises several slots formed in the support plate 60 and arranged in parallel next to one another. The number of slots and the dimensions of the slots may vary, but in the illustrated there are about thirty adjacent slots spaced about 0.64 mm apart, each slot being about 0.64 mm wide and 10.75 mm long. The slots define a total area of about 0.0004 square meter,

which total area is the measure used for flux rate calculations. The slots are fluidly connected to form the permeate passage 64 by a duct 66 running under the surface of the support plate 60. A permeate manifold 68 runs from the permeate duct 66 through the permeate fitting in the lower housing portion 52 to the permeate outlet 54.

The test setup may further include pressure sensors immediately upstream and downstream of the cross flow device 30, attached, for example, by 1.5" tri-clamp fixture ports. Low pressure drop piping preferably extends between the feed pressure sensor and the fixture gap 44 and between the retentate pressure sensor and the fixture gap 44 to assure that any pressure drop is attributable substantially to the gap 44. Downstream of the pressure sensor a diaphragm valve may be fitted to adjust the flow rate and pressure drop across the gap 44. Feed may be supplied by means of a centrifugal pump through a heat exchanger to provide feed at a uniform temperature, and the temperature may be monitored immediately upstream of the feed pressure sensor. A diaphragm valve may be fitted to the permeate outlet 54 to control TMP and permeate flow/pressure, and a permeate pressure sensor is preferably fitted upstream of the permeate valve.

The cross flow device 30 shown in Figures 3 and 4 may be analyzed in any suitable manner. For example, two pressure drop values may be used to characterize the cross flow device 30. The

first is the total feed pressure drop (PG) along the gap 44. For given gap height and length and fluid characteristics, PG dictates the wall shear rate, which is substantially constant along the length of the uniform gap 44. The second is the feed pressure drop (PM) along the portion of the gap length spanning the permeate passage 64. If P1 is the pressure at the leading edge of the permeate passage 64 and P2 is the pressure at the trailing edge of the permeate passage 64, such that PM = P1 - P2, then for the calculation of TMP, the feed pressure PF at the permeate passage is defined as PF = P2 + (0.5)(PM). TMP equals PF - PP, where PP is the permeate pressure.

The cross flow device 30 shown in Figures 3 and 4 as well as the test setup may be used for a wide variety of fluids. One example involves the filtration of raw skim milk. However, this example is not a limitation on the scope of the invention.

Example

The cross flow device 30 shown in Figures 3 and 4 and the previously described test setup incorporating the cross flow device 30 were used to filter raw skim milk (0.08% milk fat) at 127°F. The target pressure drop PG along the gap 44 was 20 psi to produce a shear rate of 7×10^5 inverse seconds.

Prior to initiating the test run, conditions were set to prevent Starling flow reverse pressure rupture of the membrane and to

prevent premature fouling of the membrane. The target feed milk flow rate was established in a bypass-to-drain upstream of the test fixture, at the target flow rate, pressure and temperature. The test fixture was prewarmed with water and the retentate valve was set to produce half the target pressure drop PG. Then the feed milk pressure was reduced to half PG; water flow to the test fixture was stopped; and milk flow was diverted into the test fixture. The permeate valve was opened very slightly to allow minor permeate flow, reducing the permeate pressure and reducing the Starling flow back-pressure. After a moment, the retentate valve was opened to provide the target gap pressure drop PG, which resulted in a total feed flow rate of about 4 liters/minute. Permeate flow was monitored and the permeate valve was adjusted accordingly to maintain the target permeate rate. During the course of the experiment, the permeate rate was increased and maintained for extended periods. The experiment was terminated after nearly six hours with little discernible fouling of the membrane.

Figures 5 and 6 show the test results. The conclusion of the flux and fouling data is that either the filtration of the raw skim milk could have continued indefinitely at the 2130 LMH (liters/meters^2 hour) flux rate, or the flux rate could have been further increased.

The example also demonstrates that extremely high shear rates can be applied in a cross-flow device while controlling the TMP or permeate flow/pressure in the small permeate channel and that

membrane fouling can be significantly reduced or prevented by the extremely high shear rates, which eliminate gel layer formation and allow the porous membrane characteristics to more fully participate in the separation process.

The example also demonstrates that practical, reliable control of TMP in a cross-flow device can be achieved even at extremely high feed flow rates, shear rates, and gap pressure drop by the use of a low-resistance permeate channels preferably oriented perpendicular to the feed flow direction and devices such as valves to control permeate flow and pressure.

Further, the example may be subject to several modifications. For example, a series of geometrically parallel permeate channels may be configured to extend more or all of the length of the gap. The width of the permeate channels may be increased or decreased, for example, to address Starling flow at startup particularly or to address membrane characteristics such as strength or fouling tendencies in the subject feed fluid. Multiple cross-flow gaps may be configured in parallel and their associated permeate channels having the same permeate pressure may be shared or manifolded to a common control valve. Additional cross-flow gaps and clusters of gaps and permeate passages as described previously may be configured in series to take advantage of feed flow capacity or by adding booster pumps between the individual clusters.

Although aspects the present invention have been described with respect to planar cross flow devices and processes, the invention is not limited to this feature. Modifications may be made and alternatives may be utilized by those skilled in the art, particularly in light of the foregoing teachings. For example, cylindrical or tubular cross flow devices and processes may also embody various aspects of the invention.

One example of a cylindrical cross flow device 80, which is illustrated in Figures 7 and 8, comprises a cylindrical cartridge 82 which includes an impermeable cylindrical shell 84 and a separation pack 86 positioned in the shell 84. The separation pack 85 may comprise a central spool 88 and one or more separation leaves 90 wrapped around the spool 88 to define narrow gaps 92 between adjacent leaves 90 which serve as shear regions 94 of the feed channels. A feed fluid stream is directed into a first end of the cartridge 82 where it flows into a first end of the separation pack 86 axially through the gaps 92 along the narrow feed channel shear regions 94 to the second end of the separation pack 86. The separation pack 86 is preferably sealed within the shell 84, for example, by a potting material 96 such as a polyurethane. The potting material 96 prevents feed fluid from bypassing the separation pack 86 along uncontrolled gaps, e.g., between the shell 84 and the separation pack 86. Other sealing mechanisms are

disclosed, for example, in International Application No. PCT/US99/20509, which is incorporated by reference. Alternatively, the separation pack and the shell may be arranged to define a narrow outer gap between the outermost leaf (leaves) and the shell similar to the narrow gaps within the cartridge, thereby providing a shear region on a porous medium interfacing with this gap.

The separation pack 86 separates the feed fluid stream into a permeate stream and a retentate stream. The permeate stream and the retentate stream may exit the cylindrical cartridge 92 in any suitable manner which isolates the permeate stream from the retentate stream. In the illustrated embodiment, the permeate stream preferably exits the cylindrical cartridge 82 via a permeate outlet conduit 98 which extends from the second end of the separation pack 86 through the shell 84. The retentate stream preferably flows from the second end of the separation pack 86 through a thrust grate 100 and the exits through the open second end of the cylindrical cartridge 82. The thrust grate 100 preferably contacts the separation leaves 90 and reacts thrust from the retentate stream due to the feed fluid pressure drop through the feed channels from the first end to the second end of the separation pack 86. The thrust grate 100 may be configured in a wide variety of ways and is preferably attached to the shell 84 in order to transmit thrust forces to the shell 84 and help maintain, reduce forces on, and thereby the separation leaves 90 in place. However,

the thrust grate 100 may be attached to the second end of the separation pack 86 in any other suitable location, for example, at the end of the spool 88.

The separation pack may be configured in a variety of ways. For example, in the illustrated embodiment, the separation pack 86 comprises a central permeate collection spool 88 and one or more separation leaves 90 coupled to and wrapped, preferably spirally, around the spool 88. As shown in Figure 9, the spool 88 preferably has a volute configuration for centrally supporting the one or more spirally wrapped separation leaves 90. The spool 88 may also include one or more passages (not shown) for fluidly communicating permeate from the separation leaves 90 to the permeate outlet conduit 98.

As shown in Figures 10-12, each separation leaf 90 may include a permeate grid 102, a porous medium 104, such as a porous membrane, preferably mounted to each of the opposing broad faces of the permeate grid 102, and a header 106, 108 mounted to each end of the permeate grid 102. The permeate grid 102 is preferably relatively thin and has sufficient flexibility to allow the leaf 90 to be wrapped around the spool 88 and the other leaves 90. The permeate grid 102preferably comprises a polymeric material and may be formed as an extrusion, a rolled extrusion, a rolled film, a molded structure, such as an injection molded structure, or, less preferably, a machined grid.

The permeate grid 102 preferably includes a plurality of parallel ribs 110 which define a plurality of permeate passages 102, such as permeate grooves. The permeate ribs 110 and grooves 112 are preferably oriented substantially perpendicularly to the feed flow direction. Each permeate groove 112 is preferably large enough in cross section that the pressure drop from the outer end to the inner end along the groove due to permeate flow is relatively small compared to the pressure drop through the membrane 104 or the pressure drop from the feed end to the retentate end of the separation pack 86. The permeate grid 102 also preferably has leading and trailing edges 114, 116 which are profiled to provide a smooth transition for feed flow into the separation pack 86 and for retentate flow out of the separation pack 86. Further, the permeate grid 102 may have one or more steps 118 on both broad faces defining pockets within which the porous medium 104 may be attached. Steps 118 may be preferred where the porous medium 104 includes more than one layer.

The porous medium 104 may comprise one or more layers, preferably including at least one supported or unsupported porous membrane, and is attached to the permeate grid 102 in any suitable manner. A single membrane may be secured to each broad face of the permeate grid 102 by attaching and sealing the membrane to the ribs 110 and the step 118 in any suitable manner, including solvent or adhesive bonding or heat sealing. Attachment

to the ribs 110 provides support for the membrane 104 against back pressure to prevent it from rupturing and to prevent it from billowing, which might decrease the height of the feed channel gap. Further, attaching the membrane 104 to the ribs 110 isolates the permeate grooves 112 from one another within the permeate grid 102. Securing the membrane 104 to the steps 118 within the pocket ensures the membrane 102 is substantially flush with the surface of the leading and trailing edges 114, 116, preventing flow discontinuities and damage to the membrane from fluid flow. Alternatively, the permeate grid may not be stepped and the porous membrane may extend outside the narrow gap of the feed channel and be bonded to the profiled surface of the leading and trailing edges.

Where the porous medium comprises two or more layers, additional layers may be attached to additional steps or may be extended beyond the inner layer and bonded to the profiles of the leading and trailing edges. Adjacent medium layers may also be joined to one another in any suitable manner which allows permeate to penetrate the medium layers. For example, adjacent medium layers may be conjoined continuously or recurrently, e.g., in strips parallel to the permeate grooves, in order to inhibit permeate recirculation in the feed direction between medium layers, which recirculation might otherwise act to billow the medium layers due to back pressure. Preferably, the outermost medium layer is

attached in any suitable manner which results in a substantially flat medium surface interfacing with the feed channel gap.

A header 106, 108 may be attached to each end of the permeate grid 102, and, preferably, the porous medium 104 is also attached to the headers 106, 108. For example, the headers 106, 108 may be stepped in a manner similar to the permeable grid 102, and the one or more layers of the porous medium 104 may be secured in the pockets of the headers 106, 108 as previously described with respect to the permeate grid 102. Alternatively, the porous medium may be secured to the headers in any other suitable manner. For example, the porous medium may extend beyond the permeable grid onto an upper or lower surface of the header, where it may be attached. The headers 106, 108 may be formed from the same material as the permeate grid 102, e.g., a polymeric material. Where the porous medium 104 is attached by solvent bonding, both the permeate grid 102 and the headers 106, 108 may be formed from a polymeric material which is preferentially dissolvable in the solvent compared to the porous medium 104.

The header 106 which is spaced from the spool 88, i.e., the outer header, may be a blind header which terminates the permeate grooves 112, or groups of grooves, defined by the ribs 110 and porous medium 104. The blind header 106 is preferably joined to the permeate grid 102 and the porous medium 104 in a

manner which isolates each permeate groove 112, or groups of permeate grooves, from one another. The header 108 which is nearest the spool 88, i.e., the inner header, is preferably coupled to the spool 88 to allow permeate to flow from the permeate grooves 112 in the permeate grid 102 to the permeate passages in the spool 88 and, hence, to the permeate outlet conduit 98. For example, the inner header 108 may include one or more passages which communicate between the permeate grooves 112, or groups of permeate grooves, in the grid 102 and the permeate passages in the spool 88.

The devices for controlling permeate flow/pressure in each permeate groove, or group of permeate grooves, may be operatively associated with the separation cartridge in a wide variety of ways. For example, the control devices may be external to the separation cartridge. The permeate grooves, or groups of grooves, in the permeate grid may then respectively communicate with corresponding isolated permeate passages in the inner header, which may, in turn, respectively communicate with corresponding isolated permeate passages in the spool. The spool passages, may, in turn, respectively communicate with separate permeate outlet conduits or isolated permeate passages in a single outlet permeate conduit. The individual permeate streams may then be connected to the flow/pressure control devices, e.g., valves, external to the separation cartridge and fed to a common manifold.

As another alternative, the control devices may be located in the spool. The individual permeate streams corresponding to the individual permeate grooves, or groups of grooves, may flow from the inner header to the respective flow/pressure control devices in the spool. From the control devices, the permeate streams may be fed to a common passage and hence to the single permeate outlet conduit. As yet another alternative, the flow/pressure control devices may be located in the permeate grid or between the permeate grid and the header. Permeate flowing from the control devices may then be fed to common passages in the header and in the spool and, hence, to the permeate outlet conduit.

In the embodiment illustrated in Figures 12 and 13, the control devices 120 may be located in the inner header 108 and preferably comprise flow restrictors, such as orifices or capillaries. One flow restrictor 120 communicates with each permeate groove 112, or group of permeate grooves. Each restrictor 120 may be sized to provide a flow rate or pressure in the corresponding permeate groove(s) 112 that will, in turn, provide a desired TMP across the porous medium at the permeate groove(s). The permeate groove 112 or groups of permeate grooves, are preferably connected in parallel through the flow restrictors 120. From the flow restrictors 120 in the inner header 108, the permeate streams may be fed to a common passage in the spool 88 and, hence, to the permeate outlet conduit 98.

With the inner header 108 of each of the one or more separation leaves 90 coupled to the spool 88 to communicate permeate from the permeate grid 102 to the spool 88, the separation leaves 90 are wrapped around the spool 88. The leaves 90 are spaced from the spool 88 and from one another to form narrow feed gaps 92, as shown in Figure 10, including the shear regions 94 of the feed chambers. The feed gaps preferably have a height, more preferably a uniform height, in the range from about 0.07 mm or less to about 1.30 mm or more, more preferably from about 0.12 mm to about 0.38 mm.

To maintain the gap height, spacers may be associated with each separation leaf. The spacers may be arranged in a variety of ways. For example, the spacers may comprise variously shaped standoffs 122 which face outwardly from the permeate grid and are integral to the porous medium 104, as shown in Figure 14A, or to the permeate grid. Alternatively, the spacers may comprise a porous layer 124, such as a mesh or a corrugated film, which may be disposed within the feed gaps 92 between the porous media 104 with the corrugations extending axially, as shown in Figure 14B. However, the gap height is preferably maintained by spaced rods 126 axially disposed in parallel in the gaps 92 between the leaves 90 and spool 88 and between adjacent leaves 90. The rods 126 may have a variety of cross sections, e.g., circular or rectangular. The rods preferably extend from the leading edge 114 to the trailing

edge 116 of the permeate grids 102 between adjacent porous media 104, as shown in Figure 14C. The rods 126 may be fabricated from a polymeric material or a polymeric coated metal or glass and may be positioned for attachment, for example, in a loom warp arrangement and trimmed after attachment. The rods 126 are preferably solvent bonded to the porous media 104, for example, before the separation leaves 90 are wrapped around the spool 88. Alternatively, the rods 126 may be solvent bonded to the separation leaves 90 after the leaves 90 are wrapped around the spool 88. In this manner the rods 126 may be attached to both adjacent porous media 104. As yet another alternative, the rods may be adhesively attached or welded to one or both membranes. The wrapped composite assembly has a high degree of structural integrity, but bonding the rods to the porous media 104 of adjacent leaves 90 even further strengthens the assembly and may allow the thrust grate 100 to be omitted.

Although the illustrated embodiments of the cylindrical cross flow device 80 include a spool 88 having one or more permeate passages 112 coupled to a permeate outlet conduit 98, other embodiments may be configured differently. For example, the spool may be free of any permeate passages, e.g., may be a solid structure, or it be eliminated entirely. The spirally wrapped separation leaf or leaves may include one or more blind inner headers and one or more outer headers which have one or more

permeate passages fluidly communicating with the permeate grooves in the permeate grid of each separation leaf. Each outer header may be directly coupled to the cylindrical shell, and the permeate streams may be fed from the outer header through the shell to an external set of permeate flow/pressure control devices. Alternatively, the flow/pressure control devices may be located in the shell, between the shell and each outer header, in each outer header, or in the permeate grid.

A cross flow device having composite configuration of separation leaves provides a high degree of structural integrity and may be utilized in a rectangular cross flow device, as well as a cylindrical cross flow device. For example, rectangular cross flow cartridges 130, 130', embodying the invention are shown in Figures 15 and 16. Each of the devices 130, 131' includes a stack of separation leaves 132, each similar to the separation leaf 90 shown in Figures 10-12. The leaves 132 are stacked such that the headers of adjacent leaves 132 lie atop one another with their leading and trailing edges aligned and a narrow rectangular gap 134 including the shear region 136 between adjacent leaves 132. Standoffs on the headers or shims between the headers may be provided to define the feed gaps 134. Where spacers, such as rods or porous medium standoffs, are provided in the feed gaps between the leaves 132, the header standoffs or shims may have substantially the same height as the spacers. Alternatively or additionally, the

permeate grid may be formed to have sufficient structural rigidity to reduce the number of, or eliminate, the spacers, thereby decreasing the load on the membranes and the permeate grids. The stack of separation leaves 132 may be structurally joined in any suitable manner, including, for example, by an external housing or frame; by structural members such as tie rods, bolts, or running threads; by welding such as thermal or sonic welding; and/or by bonding such as adhesive or solvent bonding.

The permeate grids, porous media, and headers of a rectangular cross flow cartridge 130, 130' may be substantially similar to those described for a cylindrical cross flow cartridge 80. Preferably, however, the headers on both ends of the permeate grid of a rectangular cross flow cartridge 130, 130' have one or more passages for directing permeate away from the permeate grooves, or groups of grooves. The permeate flow/pressure control devices may be operatively associated with a rectangular cross flow cartridge 130, 130' in a wide variety of ways analogous to those previously described with respect to the cylindrical cross flow cartridges.

In the embodiments illustrated in Figures 15 and 16, each opposite header combines the permeate streams from a group of permeate grooves to form a permeate channel, where a permeate channel may be defined as one or, preferably, more permeate groove streams combined upstream from a permeate flow/pressure

control device. Permeate channels are preferably isolated from and independent of one another. For example, as shown in Figures 17A-17D, each header 138 of the rectangular cross flow cartridge combines the permeate streams of four permeate grooves 140 in a single slot 142 to form a single channel 144, and each header 138 has four channels 144. Alternatively, more or fewer permeate grooves may be combined in a single channel, and more or fewer channels may be disposed in each header. Further, different channels may be formed from different numbers of permeate grooves, and different headers may have different numbers of channels. The channels 144, and corresponding permeate grooves 140, of any one header 138 are preferably isolated from and independent of one another. Further, the channels 144, and corresponding permeate grooves 140, of a header 138 at one end of a separation leaf 132 are preferably isolated from and independent of those of the header 138 at the opposite end of the separation leaf 132. Alternatively, corresponding channels on opposite headers may communicate with the same permeate grooves. While a header, such as the header 138 shown in Figures 17A-17D, is being described in the context of a rectangular cross flow cartridge, it may also be used in a cross flow cartridge having a different configuration, such as a cylindrical cross flow cartridge.

The permeate flow/pressure control devices 148 may comprise flow restrictors, such as orifices or capillaries, disposed in

each header 138 between the channel slot 142 and the channel outlet, as shown in Figures 17A-17D. The channel outlets may be fed in parallel to a common permeate outlet conduit. However, in the embodiments illustrated in Figures 15 and 16, the channels 144 of the separation leaves 132 are grouped, for example, in eight groups corresponding to channel number one, channel number two, etc., according to the location of a channel 144 along the feed gap 134. Similarly situated channels 144 are fed to a common permeate duct 150 that may extend along the height of the stack of separation leaves 132. The permeate ducts 150 are preferably isolated from one another, e.g., the permeate duct 150 collecting permeate from all number one channels or number two channels, etc., are isolated from the other permeate ducts 150. Permeate may be taken from the permeate ducts 150 in a variety of ways, as shown in Figures 15 and 16. One advantage of separate permeate ducts 150 is that it allows an independent analysis of the permeate collected from similarly situated channels 144. Preferably, the permeate streams in the permeate ducts 150 are combined downstream in a single permeate outlet conduit.

The embodiment illustrated in Figure 18 comprises a plurality of, e.g., two, rectangular cross flow cartridges 130 connected with their permeate ducts 150 in parallel. Alternatively, the cartridges may be connected with their permeate ducts in series or in various series/parallel arrangements. Feed fluid is preferably directed in

parallel to the plurality of cartridges 130 from a common pressure source. Feed fluid may, alternatively, be directed in series through two or more cartridges. However, it is preferable to boost the pressure of the feed fluid as it exits a first cartridge and before it enters the second cartridge downstream in the feed stream in order to compensate for the feed-inlet-to-retentate-outlet pressure drop in the first cartridge. For example, a pump may be positioned in the feed stream between the first and second cartridges. While various series and/or parallel arrangements of cartridges are being discussed in the context of rectangular cross flow cartridges, these arrangements may be provided for cartridges having different configurations, including, for example, cylindrical configurations.

Each of the plurality of cartridges 130 are preferably substantially identical to the other cartridges. This allows the same permeate flows/pressures (and TMPs) to be produced for corresponding permeate channels in the various cartridges 130, resulting in a balanced, substantially equal flow from corresponding channels in the cartridges 130. Each rectangular cross flow cartridge 130 may be similar to the rectangular cross flow cartridge 130 shown in Figure 15 except the permeate flow/pressure control devices are external to the cartridge. The headers in the rectangular cross flow cartridges 130 of Figure 18 may be similar to those shown in Figures 17A-17D except the flow restrictors 146 are omitted and permeate passages 140 or groups of permeate

passages, which do not function as flow restrictors, extend from the channel slot-to-the-channel outlet and, hence, to the corresponding permeate duct 150. The permeate ducts 150 are preferably arranged such that the permeate duct 150 which collects permeate from the n^{th} channel in the first rectangular cross flow cartridge 130 is connected in parallel with the permeate duct 150 which collects permeate from the n^{th} channel in the second rectangular cross flow cartridge 130. The parallel arrangement of permeate ducts 150 is preferably fed to a set of permeate flow/pressure control devices 152, such as control valves, external to the rectangular cross flow cartridges 130. The permeate control valves 154 may, for example, be mounted on a control skid and the outlet of each control valve may be fed in parallel to a common permeate outlet 154. Alternatively, the permeate flow/pressure control devices may be mounted to one or both rectangular cross flow cartridges, in the permeate ducts, or in any of the other locations previously described.

Each of the rectangular cross flow cartridges may be contained in a frame or a housing (not shown) which transitions feed flow from circular cross section piping to the feed inlets of the rectangular cartridge and transitions retentate from the retentate outlets of the rectangular cartridge to circular cross section retentate piping. Baffles (not shown) may be provided in the housing to distribute fluid flow in the transition zones. The interface

between the housing and the rectangular cross flow cartridge is preferably configured with seals (not shown) to prevent feed fluid from bypassing the shear regions of the feed gaps and to isolate feed fluid and retentate from permeate. A thrust grate (not shown) may be positioned against the separation leaves at the retentate outlet side of the rectangular cross flow cartridge and may be connected to the cartridge or, more preferably, to the housing.

Another example of a cross flow device 170 is represented in Figures 19-21. In this device at least one and preferably two or more stacked filter elements 172 are arranged within a housing. Each filter element 172 has at least one porous medium 174, and preferably two opposite porous media 174, overlying a permeate passage 176. The filter elements 172 may be arranged in the housing in any suitable manner, for example, in a housing or as a self-contained stack arrangement with manifolds, to provide a feed channel which includes a narrow gap 178 having a shear region 180 operatively associated with the porous media 174. The gap 178 preferably has a height in the range from about 0.03 mm or less to about 1.30 mm or more. The gap may be void or it may comprise any suitable porous material or a channeled material, such as a mesh or corrugated material, through which the feed fluid may flow. The gap may be void or it may comprise a porous material through which the feed fluid may flow. In the illustrated embodiment, the feed channel extends between a central feed inlet 179 and

peripheral retentate outlets 181, feed fluid being directed inside-out through the stack-of-filter elements 172. Inside-out flow is particularly preferred because the filter elements participate in dissipating the feed inlet-to-retentate outlet differential pressure. Alternatively feed fluid may be directed outside-in through the stack. In accordance with another aspect of the invention the filter element 172 includes only one permeate passage 176 operatively associated with the shear region 180 and the permeate passage 176 has a width in the direction of feed flow of less than about 40 mm. Limiting the width to less than about 40 mm facilitates control of the permeate flow and/or pressure within the permeate passage 176. Consequently, a permeate flow/pressure control device may be omitted. The permeate passage may be void or it may comprise a porous or channeled material. The permeate passage may be a void or it may comprise a porous material through which the permeate may flow. Permeate from the filter elements 172 may be supplied to a common permeate manifold 182 and directed to a permeate outlet 184. The permeate manifold may be located anywhere along the filter elements and may extend in any suitable direction to collect permeate from the permeate passages and direct it to the permeate outlet.

In the illustrated embodiment, each filter element 172 has a hollow, generally circular configuration. However, the filter elements may have any suitable configuration, including, for

example, a hollow rectangular, e.g., square, or triangular or elliptical or any other closed configuration. Alternatively, the filter elements may have a non-polygonal configuration, such as the configuration of the previously described separation leaves. As yet another alternative, the feed fluid may be directed along a gap, preferably center fed, adjacent a single flat filter element. However, a hollow polygonal, including hollow circular, configuration is preferred because it allows the feed fluid to pass through the shear region in a plurality of dimensions, e.g., in both the x and y Cartesian dimensions. This better balances the forces acting on the cross flow device 170 and allows for a lighter, less structurally complex housing. Generally, any suitable multidimensional configuration with a repeated pattern may be utilized.

Further, the filter elements 172 may be fashioned in a variety of ways. For example, in the illustrated embodiment the porous medium 174 may be supported on a support plate 186. The support plate 186 may be fashioned in a manner similar to the previously described permeate grids, including a profiled leading edge 188, a profiled trailing edge 190, and a plurality of ribs 192 extending between the leading and trailing edges 188, 190. The ribs 192 preferably include openings 194 allowing the permeate to flow within the permeate passage 176 to a radially extending permeate duct 196 coupled to the permeate manifold 182. Each support plate may include two or more permeate ducts and the

permeate manifold may include a corresponding number of axial conduits attached, preferably symmetrically, to the stack of filter elements. The manifold conduits may then provide structural support for the stack of filter elements as well as drain permeate to the permeate outlet.

The permeate passage 176 of the illustrated embodiment has a width of less than about 40 mm, preferably less than 20 mm, less than about 15 mm, less than about 10 mm, less than about 5 mm, or even about 1 mm or less. Limiting the width facilitates control of the permeate flow and/or pressure and obviates the need for a permeate control device such as valve, capillary or orifice. However, a permeate control device may be arranged with the cross flow device in any suitable manner, e.g., with the permeate ducts or the permeate conduits.

The porous media 174 overlying the permeate passage 176 may include any of the porous media previously described, including a porous membrane as well as a porous membrane support. While the illustrated embodiment includes both a porous membrane and a porous membrane support, some embodiments may omit the membrane support. Further, the porous media 174 may be bonded to the support plate 186 as previously described, including by solvent bonding.

Cross flow devices embodying this aspect of the invention provide very high shear rates, even with low feed inlet-to-retentate

outlet differential pressures; simple, effective permeate control; and effective separation with little or no recirculation of the feed fluid. Yet, their structure need not be complex. Further, two or more cross flow devices may be connected in series, in parallel, or in a variety of series/parallel arrangements. Further, these arrangements may be modified during the course of operation, for example, at start-up to prevent Starling flow or after prolonged operation to counter pressure differential increases.

The various aspects of the invention has been described with respect to many embodiments. However, the invention is not limited to these embodiments. For example, one or more of the features of any of these embodiments may be combined with one or more of the features of the other embodiments without departing from the scope of the invention. Further, one or more of the features of any of these embodiments may be modified or omitted without departing from the scope of the invention. Accordingly, the various aspects of the invention include all modifications encompassed within the spirit and scope of the invention as defined by the following claims.

Claims

1. A separation device comprising in the direction of feed flow:

a feed channel including a shear region having a length;

no more than one permeate passage operatively associated with the shear region of the feed channel, the permeate passage extending generally perpendicular to the direction of feed flow and having a width in the direction of feed flow which is less than the length of the shear region of the feed channel; and

a porous medium positioned between the shear region of the feed channel and the permeate passage.

2. A separation device comprising:

a feed channel including a shear region;

a plurality of permeate passages operatively associated with the shear region of the feed channel, the plurality of permeate passages including at least first and second permeate passages isolated from one another; and

a porous medium positioned between the shear region of the feed channel and the permeate passages.

3. A separation device comprising:

a feed channel including a shear region;

a plurality of permeate passages operatively associated with

the shear region of the feed channel;

at least first and second flow/pressure control devices, each control device being arranged to control permeate flow or pressure within at least one permeate passage independently of the flow or pressure within another permeate passage; and

a porous medium positioned between the shear region of the feed chamber and the permeate passages.

4. A separation device comprising:

a feed channel including a shear region;

no more than one permeate passage operatively associated with the shear region of the feed channel, the permeate passage extending generally perpendicular to the direction of feed flow in the feed channel and having a width in the direction of feed flow of less than about 20 mm; and

a porous medium positioned between the shear region of the feed channel and the permeate passage.

5. A separation process comprising:

generating a shear layer in a feed fluid; and

passing permeate from the shear layer into a first permeate passage and passing permeate from the shear layer into a second permeate passage isolated from the first permeate passage.

6. A separation process comprising:

generating a shear layer in a feed fluid;

passing permeate from the shear layer into first and second permeate passages; and

controlling the permeate flow/pressure in the first and second permeate passages independently of one another.

7. A separation process comprising:

generating a shear layer in a shear region at a porous medium; and

independently controlling TMP incrementally along the length of the shear region.

ABSTRACT

Devices and processes embodying the invention utilize a feed fluid shear layer from which permeate is passed into a permeate passage. In one embodiment of the invention, fluid is directed through a cross-flow device 10, e.g., into one or more feed inlets 16 and along feed channels to one or more retentate outlets 18. A shear layer is generated within each feed channel, and permeate is passed from the feed channel through a porous medium into one or more permeate passages 22. Permeate flow or pressure within the permeate passages may be controlled, for example, by flow restictors or valves 24A...24J.

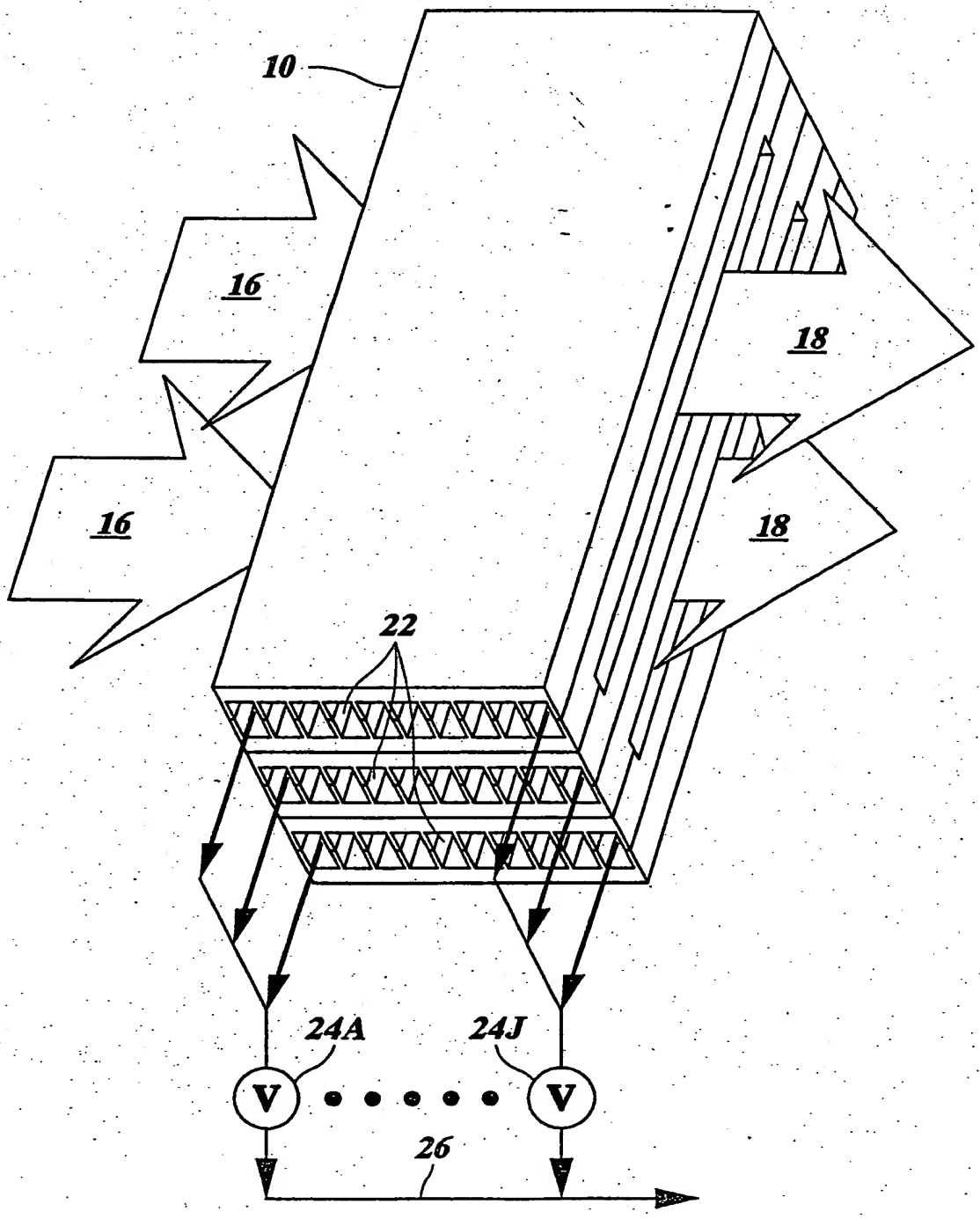


FIGURE 1

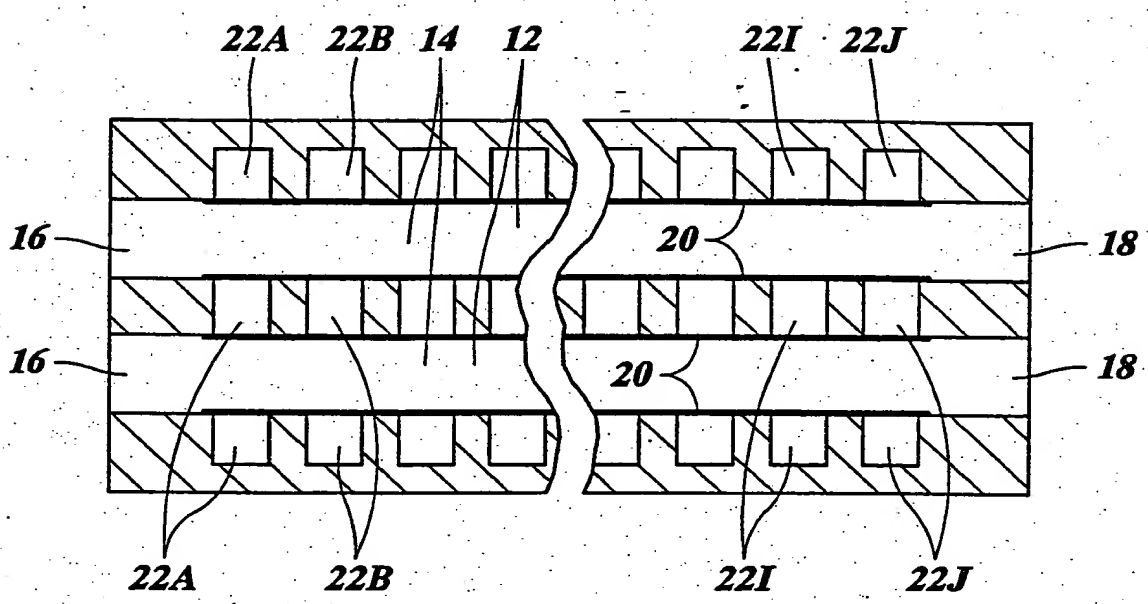


FIGURE 2

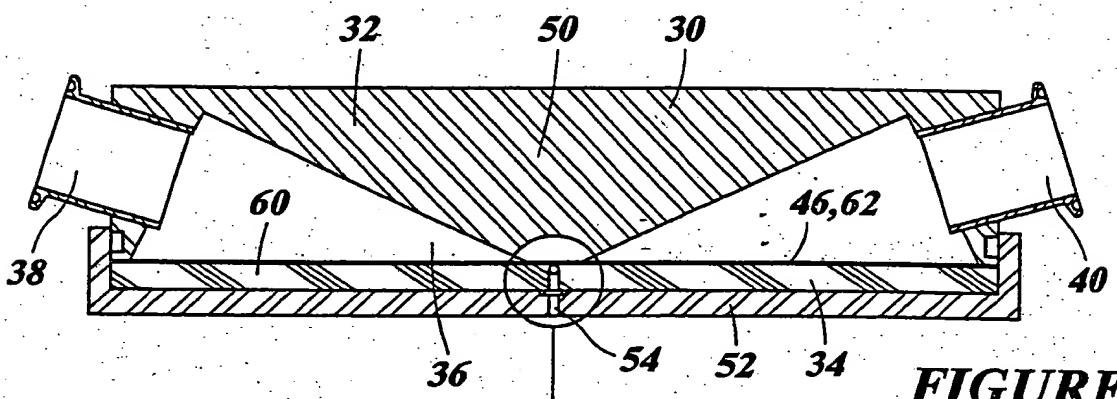


FIGURE 3

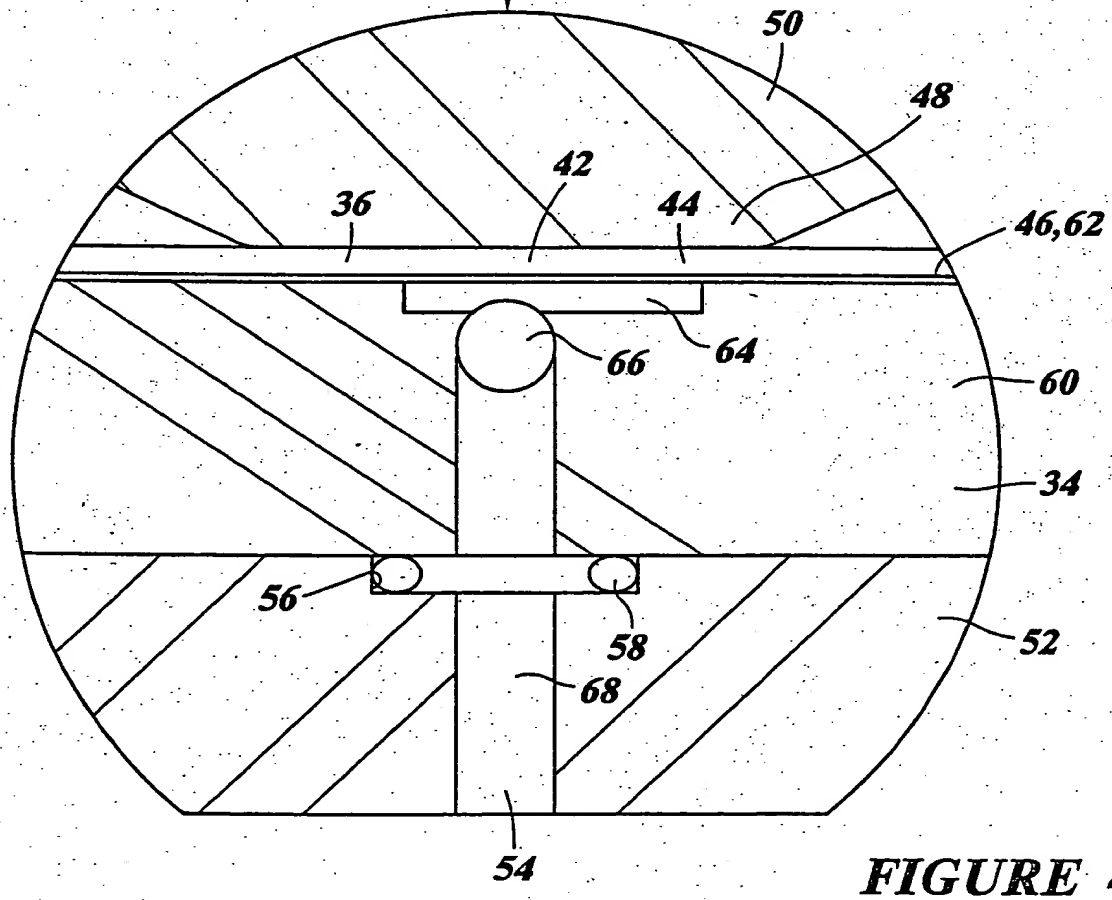
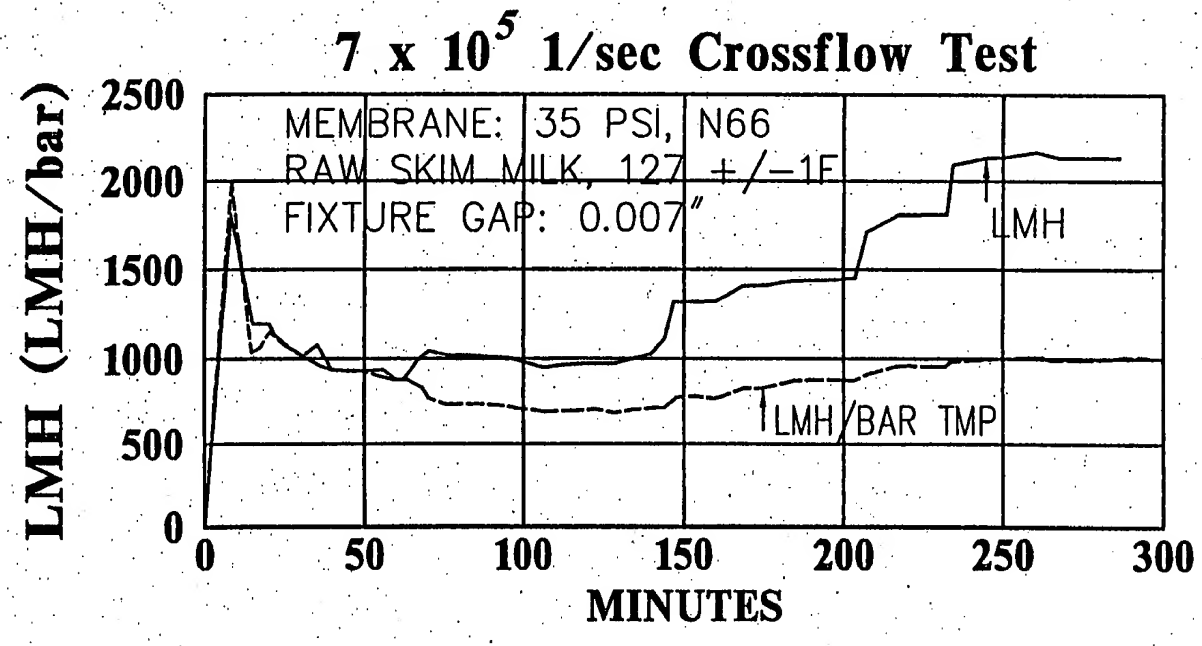


FIGURE 4

FIGURE 5



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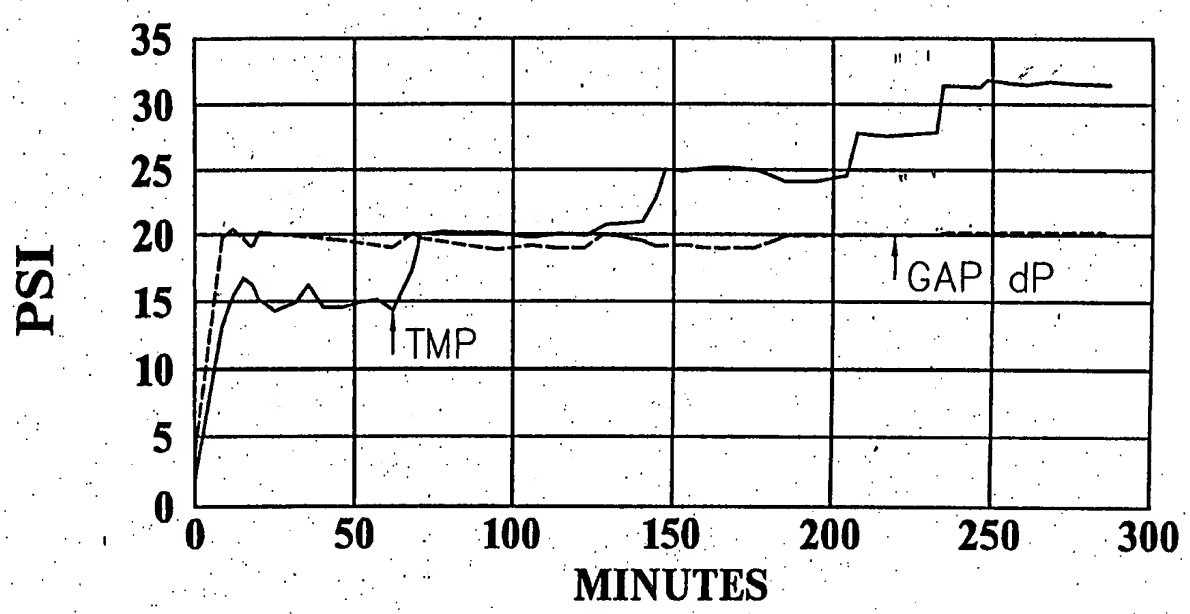

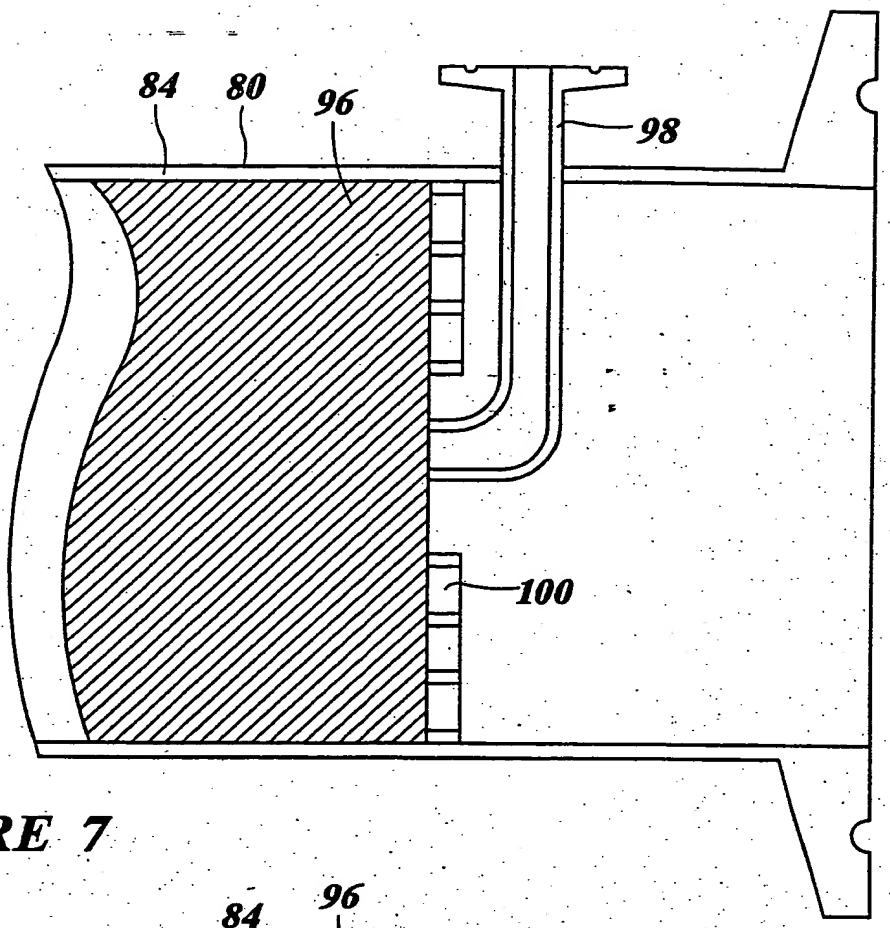

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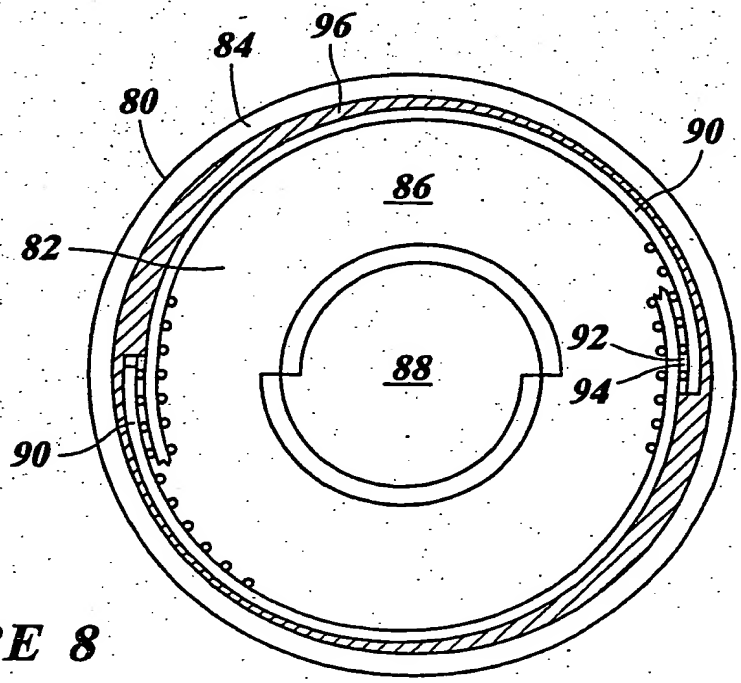

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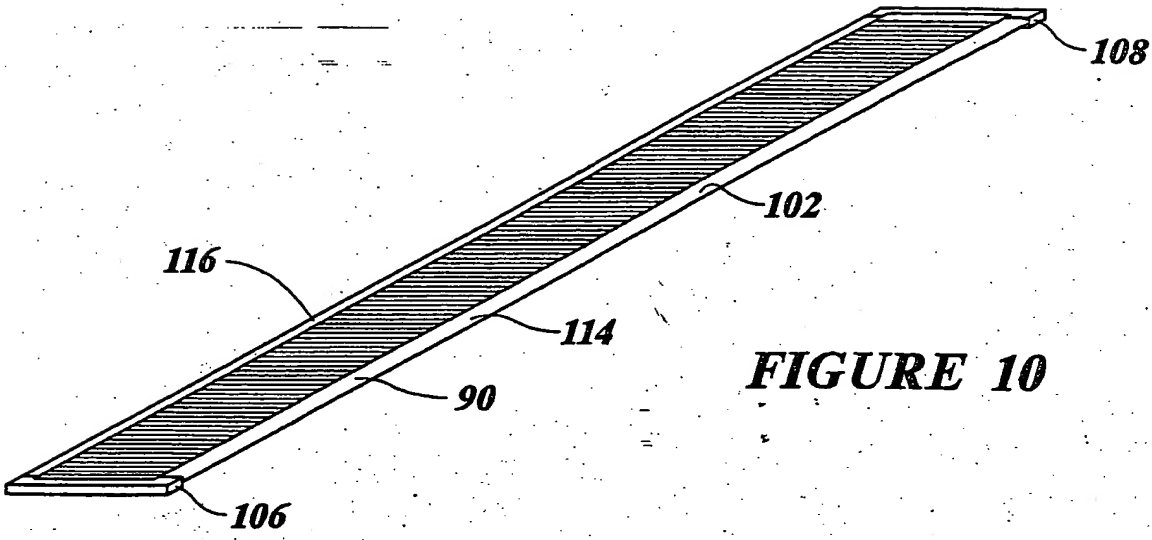

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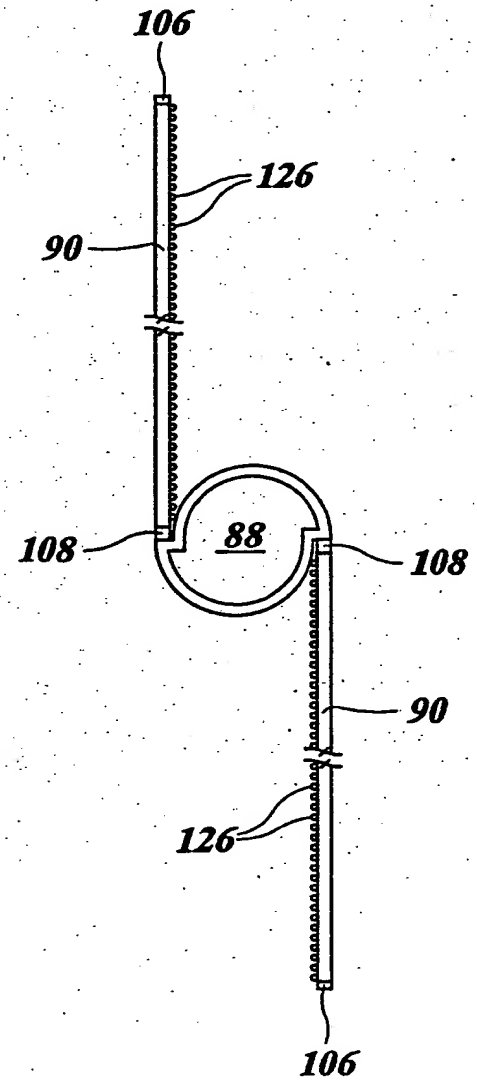

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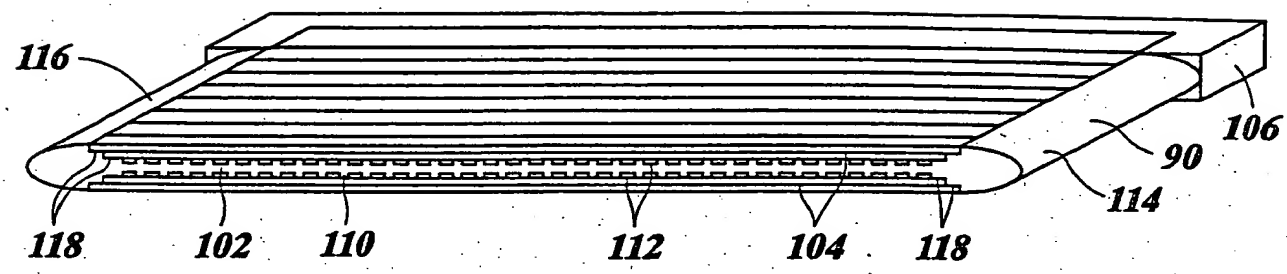

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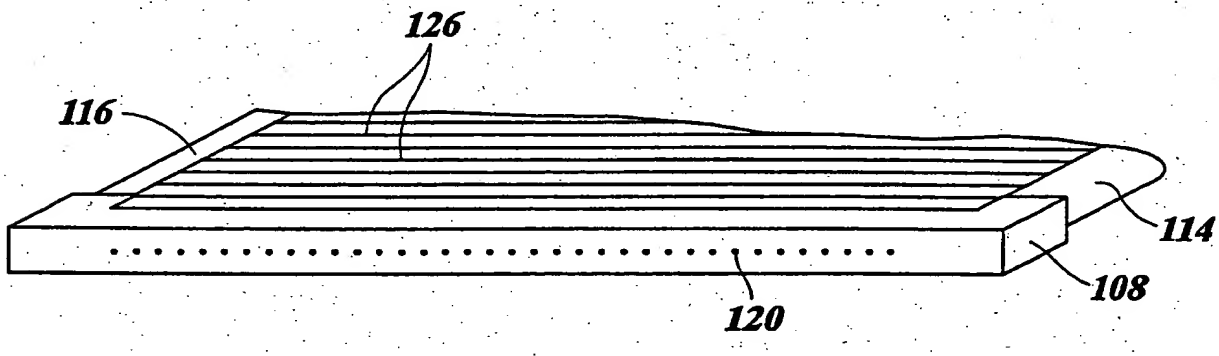

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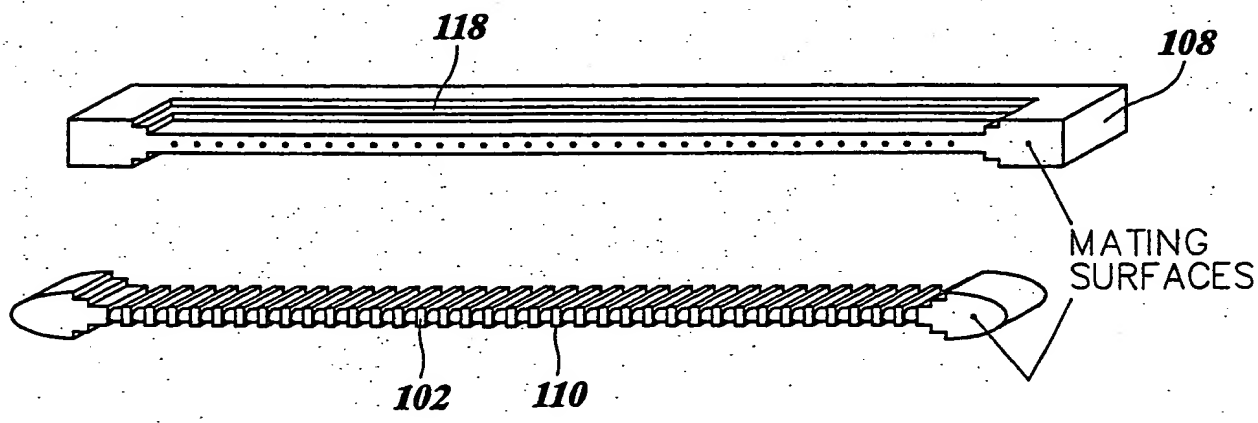

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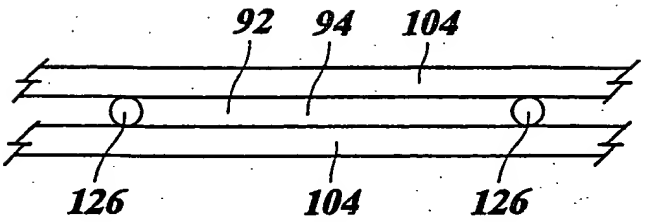


FIGURE 14C

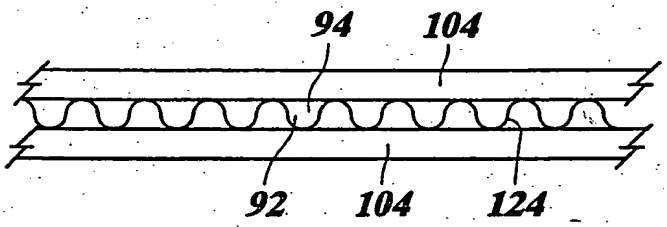


FIGURE 14B

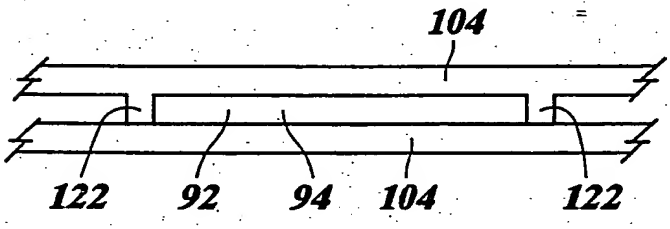


FIGURE 14A

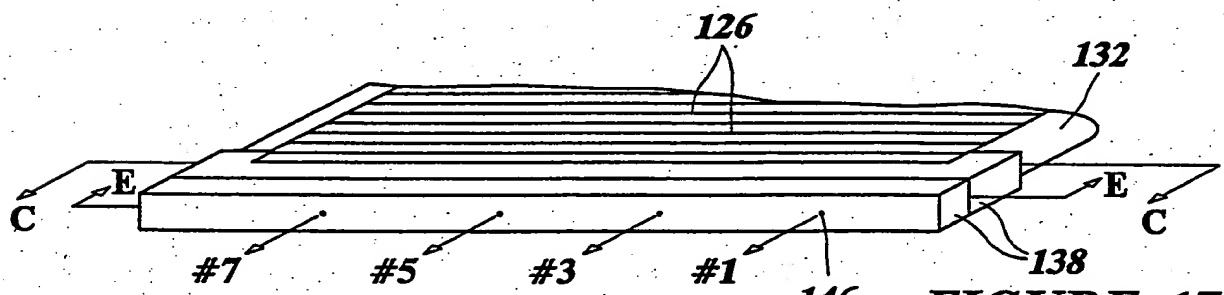
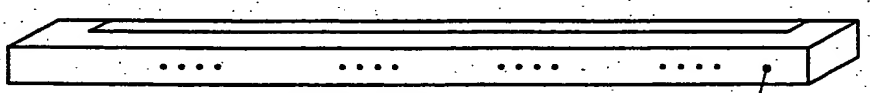
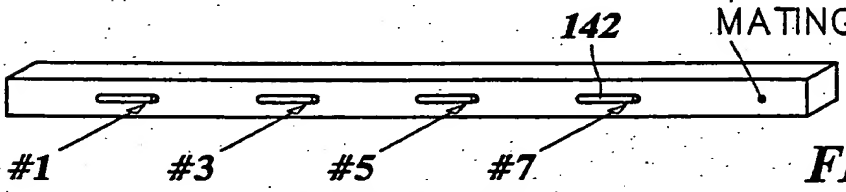


FIGURE 17A



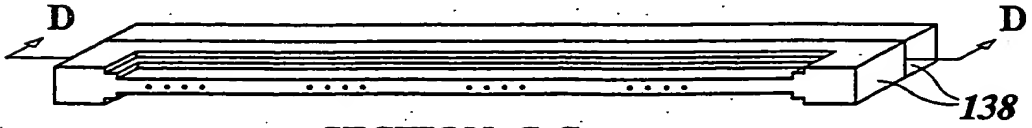
SECTION E-E

FIGURE 17D



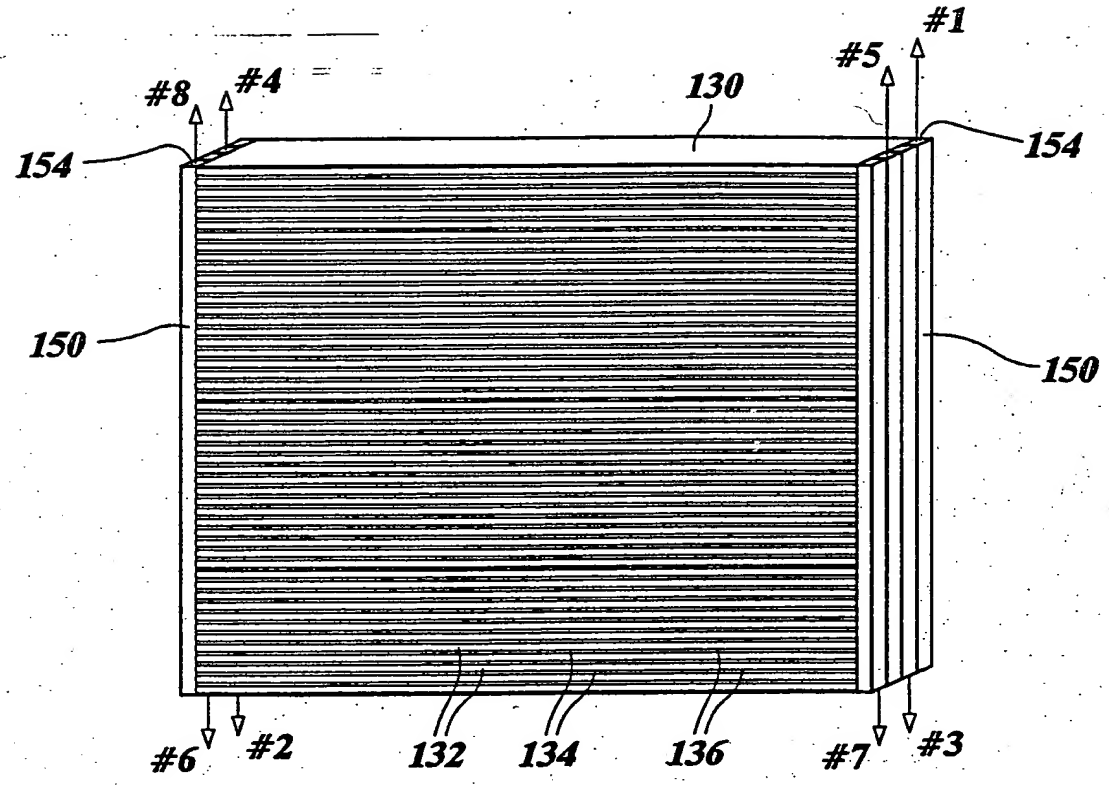
SECTION D-D

FIGURE 17C



SECTION C-C

FIGURE 17B



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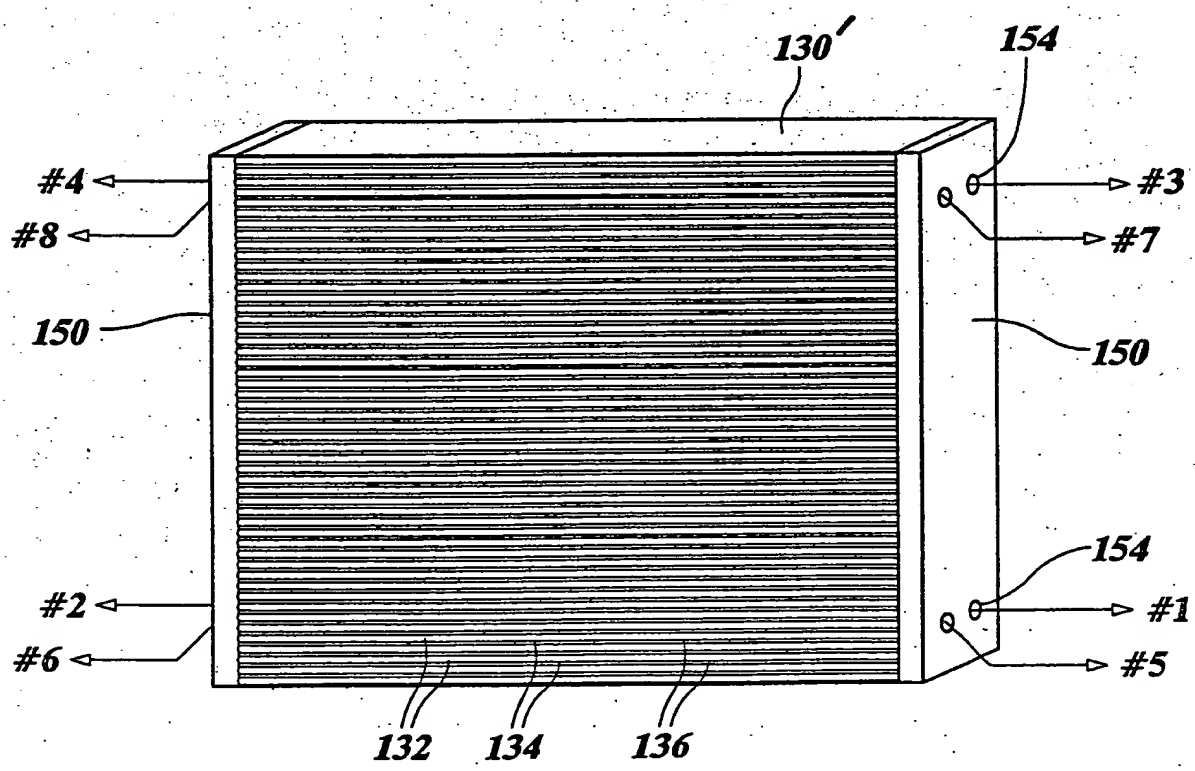

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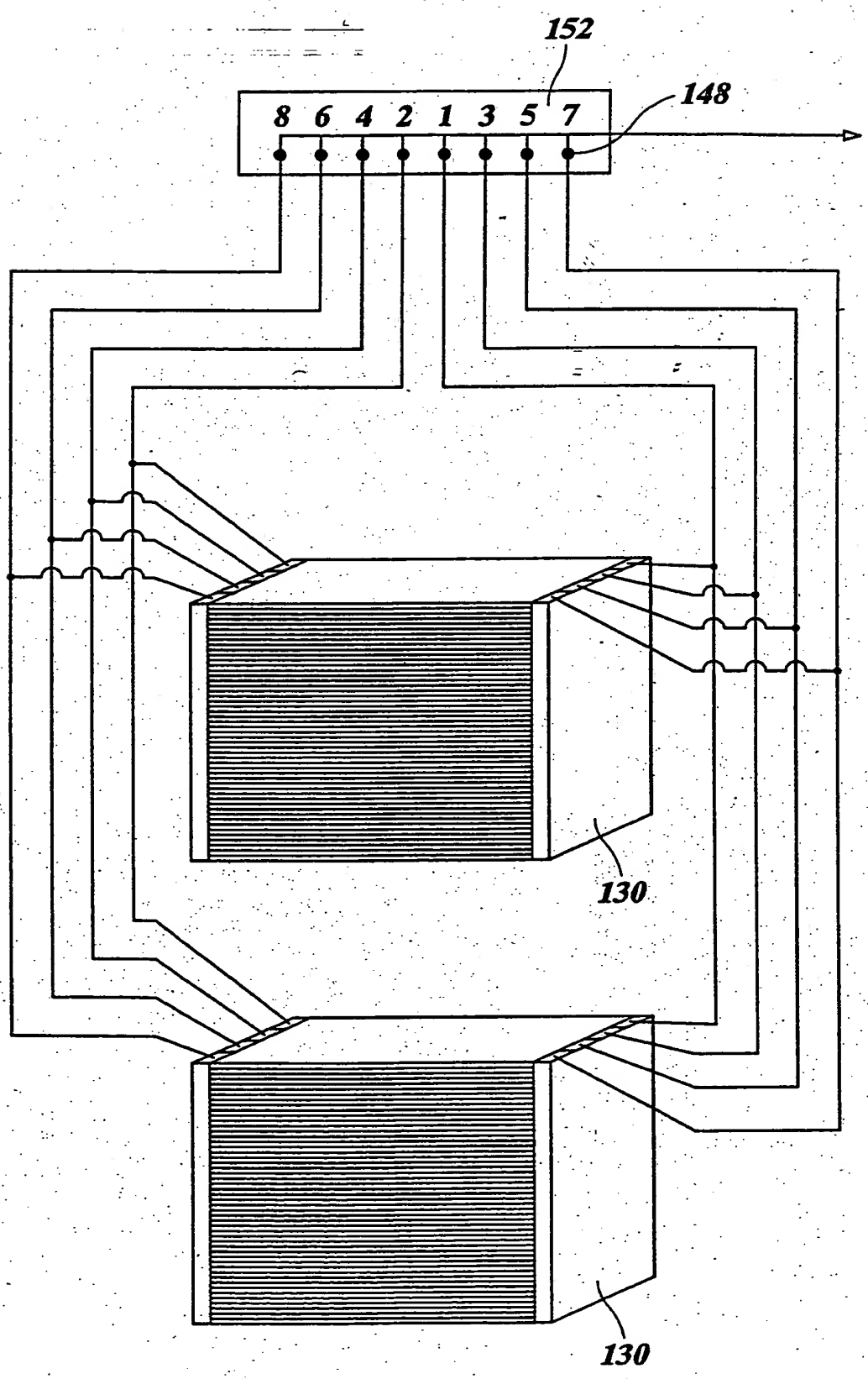


FIGURE 18

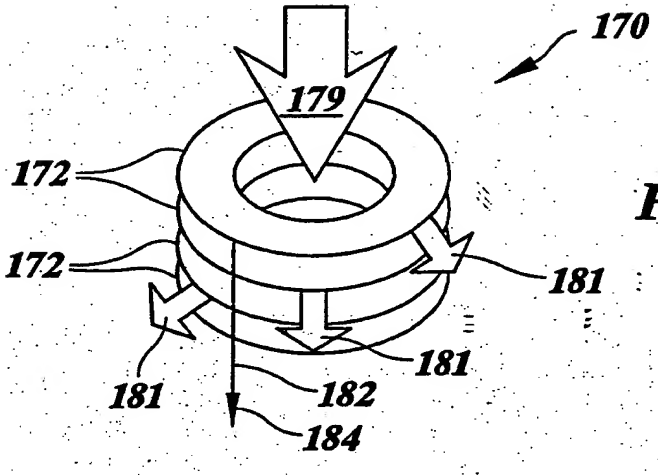


FIGURE 19

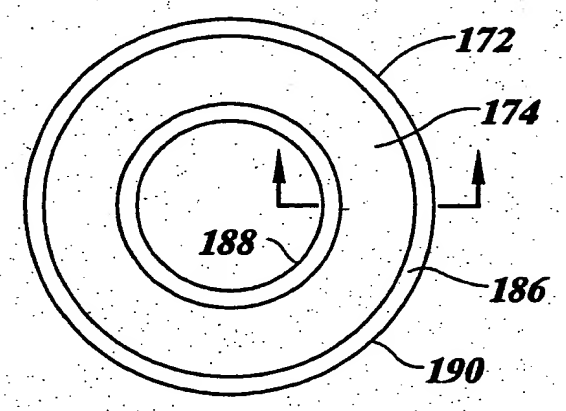


FIGURE 20

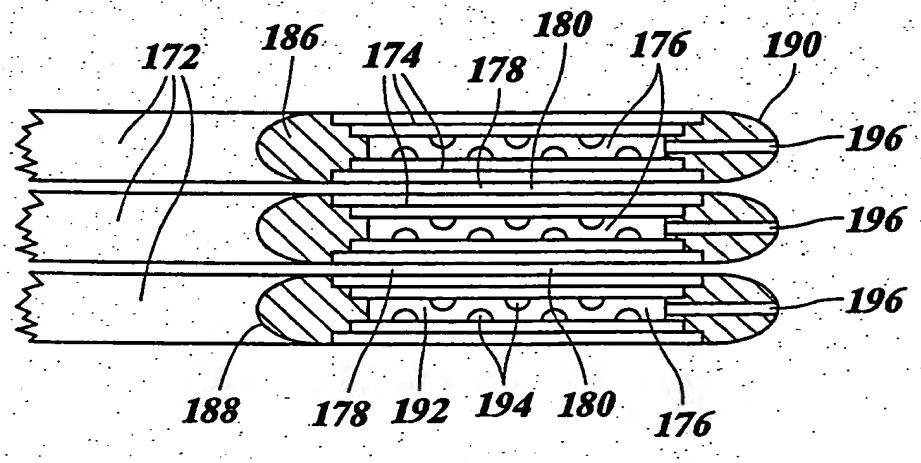


FIGURE 21

PATENT
Attorney Docket No. 440490

COMBINED DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION AND POWER OF ATTORNEY

☐ Declaration Submitted with Initial Filing OR
☒ Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16(e)) required)

As a below named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name. I believe I am the original, first, and sole inventor *(if only one name is listed below)* or an original, first, and joint inventor *(if plural names are listed below)* of the subject matter which is claimed and for which a patent is sought on the invention entitled:

SEPARATION DEVICES AND PROCESSES

the specification of which:

☐ is attached hereto.
☐ was filed on as Application No. and was amended on *(if applicable)*.
☐ was filed by Express Mail No. *as Application No. not known yet*, and was amended on *(if applicable)*.
☒ was filed on January 31, 2000 as PCT International Application No. PCT/US00/02071

I state that I have reviewed and understand the contents of the specification identified above, including the claim(s), as amended by any amendment referred to above.

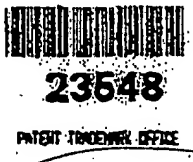
I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.

I claim foreign priority benefits under 35 USC 119(a)-(d) or (f), or 365(b) of any foreign application(s) for patent, inventor's or plant breeder's rights certificate(s), or 365(a) of any PCT international application(s) designating at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application(s) for patent, utility model, design registration, inventor's or plant breeder's rights certificate(s), or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter and having a filing date before that of the application(s) from which the benefit of priority is claimed.

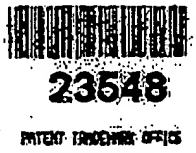
Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Claimed YES	Priority Claimed NO	Certified Copy Attached? YES	Certified Copy Attached? NO
			☐	☐	☐	☐
			☐	☐	☐	☐
			☐	☐	☐	☐
			☐	☐	☐	☐

In re Appln. of FENDYA, ET AL.
Attorney Docket No. 440490

As a named inventor, I hereby appoint Leydig, Voit & Mayer, Ltd. to prosecute this application and transact all business in the Patent and Trademark Office connected therewith: Customer Number 23548.



I further direct that correspondence concerning this application be directed to Leydig, Voit & Mayer, Ltd.: Customer Number 23548.



I declare that all statements made herein of my own knowledge are true, that all statements made on information and belief are believed to be true, that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full name of **sole or first inventor:** Thomas J. Fendya

Inventor's signature _____

Date _____ Country of Citizenship: USA

Residence: Homer, New York

Post Office Address: 137 North Main Street, Homer, NY 13077

Full name of **second joint inventor:** Mark F. Hurwitz

Inventor's signature _____

Date _____ Country of Citizenship. USA

Residence: Ithaca, New York

Post Office Address: 345 Snyderhill Road, Ithaca, NY 14850

In re Appln. of FENDYA, ET AL.
Attorney Docket No. 440490

Full name of **third joint inventor**: John D. Miller

Inventor's signature _____

Date 3/8/02

Country of Citizenship: USA

Residence: Ithaca, New York

Post Office Address: ~~511 Kline Road, Ithaca, NY 14850~~ 39-45 48th St. Sunnyside, NY 11104

NY

Full name of **fourth joint inventor**: Stephen A. Geibel

Inventor's signature _____

Date _____

Country of Citizenship: USA

Residence: Cortland, New York

Post Office Address: 31 Prospect Terrace, Cortland, NY 13045

PATENT
Attorney Docket No. 440490

COMBINED DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION AND POWER OF ATTORNEY

☐ Declaration Submitted with Initial Filing OR
☒ Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16(e)) required)

As a below named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name. I believe I am the original, first, and sole inventor *(if only one name is listed below)* or an original, first, and joint inventor *(if plural names are listed below)* of the subject matter which is claimed and for which a patent is sought on the invention entitled:

SEPARATION DEVICES AND PROCESSES

the specification of which:

☐ is attached hereto.
☐ was filed on as Application No. and was amended on *(if applicable)*.
☐ was filed by Express Mail No. *as Application No. not known yet*, and was amended on *(if applicable)*.
☒ was filed on January 31, 2000 as PCT International Application No. PCT/US00/02071.

I state that I have reviewed and understand the contents of the specification identified above, including the claim(s), as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56, including for continuation-in-part applications, material information which became available between the filing date of the prior application and the national or PCT international filing date of the continuation-in-part application.

I claim foreign priority benefits under 35 USC 119(a)-(d) or (f), or 365(b) of any foreign application(s) for patent, inventor's or plant breeder's rights certificate(s), or 365(a) of any PCT international application(s) designating at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application(s) for patent, utility model, design registration, inventor's or plant breeder's rights certificate(s), or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter and having a filing date before that of the application(s) from which the benefit of priority is claimed.

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Claimed YES	Priority Claimed NO	Certified Copy Attached? YES	Certified Copy Attached? NO
			☐	☐	☐	☐
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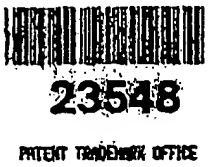
			☐	☐	☐	☐

In re Appln. of FENDYA, ET AL.
Attorney Docket No. 440490

As a named inventor, I hereby appoint Leydig, Voit & Mayer, Ltd. to prosecute this application and transact all business in the Patent and Trademark Office connected therewith: Customer Number 23548.



I further direct that correspondence concerning this application be directed to Leydig, Voit & Mayer, Ltd.: Customer Number 23548.

I declare that all statements made herein of my own knowledge are true, that all statements made on information and belief are believed to be true, that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

1 - D

Full name of sole or first inventor: Thomas J. Fendya

Inventor's signature Thomas J. Fendya

Date March 11, 2002

Country of Citizenship: USA

Residence: Homer, New York

Post Office Address: 137 North Main Street, Homer, NY 13077 NY

2 - D

Full name of second joint inventor: Mark F. Hurwitz

Inventor's signature Mark F. Hurwitz

Date March 11, 2002

Country of Citizenship: USA

Residence: Ithaca, New York

Post Office Address: 345 Snyderhill Road, Ithaca, NY 14850 NY

In re Appln. of FENDYA, ET AL.
Attorney Docket No. 440490

Full name of **third joint inventor**: John D. Miller

Inventor's signature _____

Date _____ Country of Citizenship: USA

Residence: Ithaca, New York

Post Office Address: 511 Kline Road, Ithaca, NY 14850

4th

Full name of **fourth joint inventor**: Stephen A. Geibel

Inventor's signature S A Geibel

Date March 11, 2002 Country of Citizenship: USA

Residence: Cortland, New York

Post Office Address: 31 Prospect Terrace, Cortland, NY 13045

NY

APPLICATION INFORMATION

Application Type::	Regular
Subject Matter::	Utility
Suggested classification::	
Suggested Group Art Unit::	
CD-ROM or CD-R?::	None
Number of CD Disks:	
Number of Copies of CDs::	
Sequence Submission?::	
Computer Readable From (CRF)?::	No
Number of Copies of CRF::	
Title::	SEPARATION DEVICES AND PROCESSES
Attorney Docket Number::	440490
Request for Early Publication?::	No
Request for Non-Publication?::	No
Suggested Drawing Figure::	
Total Drawing Sheets::	11
Small Entity::	No
Licensed US Govt. Agency::	
Contract or Grant Numbers::	
Secrecy Order in Parent Appl.?::	No

INVENTOR INFORMATION

Inventor Authority Type::	Inventor
Primary Citizenship Country::	US
Status::	Full Capacity
Given Name::	Thomas
Middle Name::	J.
Family Name::	FENDYA
Name Suffix::	
City of Residence::	Homer

State or Prov. of Residence:: New York
Country of Residence:: USA
Street:: 137 North Main Street

City:: Homer
State or Province:: New York
Country:: US
Postal or Zip Code:: 13077

Inventor Authority Type:: Inventor
Primary Citizenship Country:: US
Status:: Full Capacity
Given Name:: Mark
Middle Name:: F.
Family Name:: HURWITZ
Name Suffix::
City of Residence:: Ithaca
State or Prov. of Residence:: New York
Country of Residence:: USA
Street:: 345 Snyderhill Road

City:: Ithaca
State or Province:: New York
Country:: US
Postal or Zip Code:: 14850

Inventor Authority Type:: Inventor
Primary Citizenship Country:: US
Status:: Full Capacity
Given Name:: John
Middle Name:: D.
Family Name:: MILLER
Name Suffix::

City of Residence:: Ithaca
State or Prov. of Residence:: New York
Country of Residence:: USA
Street:: 511 Kline Road

City:: Ithaca
State or Province:: New York
Country:: US
Postal or Zip Code:: 114850

Inventor Authority Type:: Inventor
Primary Citizenship Country:: US
Status:: Full Capacity
Given Name:: Stephen
Middle Name:: A.
Family Name:: GEIBEL
Name Suffix::
City of Residence:: Cortland
State or Prov. of Residence:: New York
Country of Residence:: USA
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REPRESENTATIVE INFORMATION

Representative Customer Number::	23548	
Representative Designation::	Registration Number::	Representative Name::

DOMESTIC PRIORITY INFORMATION

Application::	Continuity Type::	Parent Application::	Parent Filing Date::

FOREIGN APPLICATION INFORMATION

Country::	Application Number::	Filing Date::
US	60/114,972	01/29/99
WO	PCT/US00/02071	01/31/00

ASSIGNEE INFORMATION

Assignee name:: Pall Corporation

Street:: 2200 Northern Boulevard

City:: East Hills

State or Province:: New York

Country:: USA

Postal or Zip Code:: 11548-1209

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT OR THE DECLARATION

(PCT Rule 44.1)

To:
LEYDIG, VOIT & MAYER
Attn. BELZ, J.
700 Thirteenth Street, N.W.
Suite 300
Washington, D.C. 20005
UNITED STATES OF AMERICA

Date of mailing *(day/month/year)*	03/07/2000
Applicant's or agent's file reference	**FOR FURTHER ACTION** See paragraphs 1 and 4 below
440211/PALL	
International application No.	International filing date *(day/month/year)*
PCT/US 00/02071	31/01/2000
Applicant	
PALL CORPORATION	

1. [X] The applicant is hereby notified that the International Search Report has been established and is transmitted herewith.

Filing of amendments and statement under Article 19:
The applicant is entitled, if he so wishes, to amend the claims of the International Application (see Rule 46):

When? The time limit for filing such amendments is normally 2 months from the date of transmittal of the International Search Report; however, for more details, see the notes on the accompanying sheet.

Where? Directly to the International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland
Fascimile No.: (41-22) 740.14.35

For more detailed instructions, see the notes on the accompanying sheet.

2. [ ] The applicant is hereby notified that no International Search Report will be established and that the declaration under Article 17(2)(a) to that effect is transmitted herewith.

3. [ ] **With regard to the protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

[ ] the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.

[ ] no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Further action(s):** The applicant is reminded of the following:

Shortly after **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in Rules 90*bis*.1 and 90*bis*.3, respectively, before the completion of the technical preparations for international publication.

Within **19 months** from the priority date, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until 30 months from the priority date (in some Offices even later).

Within **20 months** from the priority date, the applicant must perform the prescribed acts for entry into the national phase before all designated Offices which have not been elected in the demand or in a later election within 19 months from the priority date or could not be elected because they are not bound by Chapter II.

Name and mailing address of the International Searching Authority	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Toñi Muñoz-Manneken

Form PCT/ISA/220 (July 1998)

NOTES TO FORM PCT/ISA/220

These Notes are intended to give the basic instructions concerning the filing of amendments under article 19. The Notes are based on the requirements of the Patent Cooperation Treaty, the Regulations and the Administrative Instructions under that Treaty. In case of discrepancy between these Notes and those requirements, the latter are applicable. For more detailed information, see also the PCT Applicant's Guide, a publication of WIPO.

In these Notes, "Article", "Rule", and "Section" refer to the provisions of the PCT, the PCT Regulations and the PCT Administrative Instructions respectively.

INSTRUCTIONS CONCERNING AMENDMENTS UNDER ARTICLE 19

The applicant has, after having received the international search report, one opportunity to amend the claims of the international application. It should however be emphasized that, since all parts of the international application (claims, description and drawings) may be amended during the international preliminary examination procedure, there is usually no need to file amendments of the claims under Article 19 except where, e.g. the applicant wants the latter to be published for the purposes of provisional protection or has another reason for amending the claims before international pbulication. Furthermore, it should be emphasized that provisional protection is available in some States only.

What parts of the international application may be amended?

Under Article 19, only the claims may be amended.

During the international phase, the claims may also be amended (or further amended) under Article 34 before the International Preliminary Examining Authority. The description and drawings may only be amended under Article 34 before the International Examining Authority.

Upon entry into the national phase, all parts of the international application may be amended under Article 28 or, where applicable, Article 41.

When?

Within 2 months from the date of transmittal of the international search report or 16 months from the priority date, whichever time limit expires later. It should be noted, however, that the amendments will be considered as having been received on time if they are received by the International Bureau after the expiration of the applicable time limit but before the completion of the technical preparations for international publication (Rule 46.1).

Where not to file the amendments?

The amendments may only be filed with the International Bureau and not with the receiving Office or the International Searching Authority (Rule 46.2).

Where a demand for international preliminary examination has been/is filed, see below.

How?

Either by cancelling one or more entire claims, by adding one or more new claims or by amending the text of one or more of the claims as filed.

A replacement sheet must be submitted for each sheet of the claims which, on account of an amendment or amendments, differs from the sheet originally filed.

All the claims appearing on a replacement sheet must be numbered in Arabic numerals. Where a claim is cancelled, no renumbering of the other claims is required. In all cases where claims are renumbered, they must be renumbered consecutively (Administrative Instructions, Section 205(b)).

The amendments must be made in the language in which the international application is to be published.

What documents must/may accompany the amendments?

Letter (Section 205(b)):

The amendments must be submitted with a letter.

The letter will not be published with the international application and the amended claims. It should not be confused with the "Statement under Article 19(1)" (see below, under "Statement under Article 19(1)").

The letter must be in English or French, at the choice of the applicant. However, if the language of the international application is English, the letter must be in English; if the language of the international application is French, the letter must be in French.

The letter must indicate the differences between the claims as filed and the claims as amended. It must, in particular, indicate, in connection with each claim appearing in the international application (it being understood that identical indications concerning several claims may be grouped), whether

(i) the claim is unchanged;

(ii) the claim is cancelled;

(iii) the claim is new;

(iv) the claim replaces one or more claims as filed;

(v) the claim is the result of the division of a claim as filed.

The following examples illustrate the manner in which amendments must be explained in the accompanying letter:

1. [Where originally there were 48 claims and after amendment of some claims there are 51]:
"Claims 1 to 29, 31, 32, 34, 35, 37 to 48 replaced by amended claims bearing the same numbers; claims 30, 33 and 36 unchanged; new claims 49 to 51 added."

2. [Where originally there were 15 claims and after amendment of all claims there are 11]:
"Claims 1 to 15 replaced by amended claims 1 to 11."

3. [Where originally there were 14 claims and the amendments consist in cancelling some claims and in adding new claims]:
"Claims 1 to 6 and 14 unchanged; claims 7 to 13 cancelled; new claims 15, 16 and 17 added." or
"Claims 7 to 13 cancelled; new claims 15, 16 and 17 added; all other claims unchanged."

4. [Where various kinds of amendments are made]:
"Claims 1-10 unchanged; claims 11 to 13, 18 and 19 cancelled; claims 14, 15 and 16 replaced by amended claim 14; claim 17 subdivided into amended claims 15, 16 and 17; new claims 20 and 21 added."

"Statement under article 19(1)" (Rule 46.4)

The amendments may be accompanied by a statement explaining the amendments and indicating any impact that such amendments might have on the description and the drawings (which cannot be amended under Article 19(1)).

The statement will be published with the international application and the amended claims.

It must be in the language in which the international appplication is to be published.

It must be brief, not exceeding 500 words if in English or if translated into English.

It should not be confused with and does not replace the letter indicating the differences between the claims as filed and as amended. It must be filed on a separate sheet and must be identified as such by a heading, preferably by using the words "Statement under Article 19(1)."

It may not contain any disparaging comments on the international search report or the relevance of citations contained in that report. Reference to citations, relevant to a given claim, contained in the international search report may be made only in connection with an amendment of that claim.

Consequence if a demand for international preliminary examination has already been filed

If, at the time of filing any amendments under Article 19, a demand for international preliminary examination has already been submitted, the applicant must preferably, at the same time of filing the amendments with the International Bureau, also file a copy of such amendments with the International Preliminary Examining Authority (see Rule 62.2(a), first sentence).

Consequence with regard to translation of the international application for entry into the national phase

The applicant's attention is drawn to the fact that, where upon entry into the national phase, a translation of the claims as amended under Article 19 may have to be furnished to the designated/elected Offices, instead of, or in addition to, the translation of the claims as filed.

For further details on the requirements of each designated/elected Office, see Volume II of the PCT Applicant's Guide.

PATENT COOPERATION TREAT

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	FOR FURTHER ACTION	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
440211/PALL		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/US 00/ 02071	31/01/2000	29/01/1999
Applicant		
PALL CORPORATION		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 4 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   [ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

   b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

   [ ] contained in the international application in written form.

   [ ] filed together with the international application in computer readable form.

   [ ] furnished subsequently to this Authority in written form.

   [ ] furnished subsequently to this Authority in computer readble form.

   [ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   [ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of invention is lacking** (see Box II).

4. With regard to the **title,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**

   [ ] the text is approved as submitted by the applicant.

   [X] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. 1

   [X] as suggested by the applicant.

   [ ] because the applicant failed to suggest a figure.

   [ ] because this figure better characterizes the invention.

   [ ] None of the figures.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 00/ 02071

Box III TEXT OF THE ABSTRACT (Continuation of item 5 of the first sheet)

Separation device comprising a feed channel including a shear region, permeate passage(s) extending perpendicular to the direction of the feed flow and a porous medium positioned between the shear region of the feed channel and the permeate passage(s).
Separation process comprising generating a shear layer in a feed fluid and passing permeate into the permeate passage(s).

INTERNATIONAL SEARCH REPORT

ernational Application No
PCT/US 00/02071

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B01D53/22 B01D63/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, PAJ, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 43 42 485 C (W.L. GORE) 30 March 1995 (1995-03-30) figures ---	1-7
X	DE 44 27 354 A (W.L. GORE) 8 February 1996 (1996-02-08) figures ---	1-7
A	DE 39 27 455 C (SEMPAS MEMBRANTECHNIK) 2 August 1990 (1990-08-02) the whole document ---	1-7
A	US 4 756 835 A (DONALD R. WILSON) 12 July 1988 (1988-07-12) ---	
A	US 3 993 816 A (J. BAUDET ET AL.) 23 November 1976 (1976-11-23) ---	
	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 June 2000	03/07/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Bogaerts, M

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	US 3 266 223 A (T. DRESSER ET AL.) 16 August 1966 (1966-08-16)	
A	DE 17 92 446 A (JOSEF HOELTZENBEIN) 29 April 1971 (1971-04-29)	

INTERNATIONAL SEARCH REPORT

nation on patent family members

International Application No
PCT/US 00/02071

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
DE 4342485	C	30-03-1995	EP	0658372 A	21-06-1995
			JP	7194933 A	01-08-1995
DE 4427354	A	08-02-1996	NONE		
DE 3927455	C	02-08-1990	NONE		
US 4756835	A	12-07-1988	EP	0259109 A	09-03-1988
			JP	63069503 A	29-03-1988
US 3993816	A	23-11-1976	FR	2236537 A	07-02-1975
			BE	817509 A	10-01-1975
			CH	595125 A	31-01-1978
			DE	2433421 A	30-01-1975
			GB	1472227 A	04-05-1977
			IT	1017094 B	20-07-1977
			JP	1143920 C	26-04-1983
			JP	50131875 A	18-10-1975
			JP	57034003 B	20-07-1982
			NL	7409016 A	14-01-1975
			SE	7409089 A	13-01-1975
US 3266223	A	16-08-1966	US	3318747 A	09-05-1967
DE 1792446	A	29-04-1971	NONE		

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 440211/PALL	**FOR FURTHER ACTION**	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/US00/02071	International filing date *(day/month/year)* 31 JANUARY 2000	Priority date *(day/month/year)* 29 JANUARY 1999
International Patent Classification (IPC) or national classification and IPC IPC(7): B01D 53/22, 63/08 and US Cl.: 210/321.69, 767		
Applicant PALL CORPORATION		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 5 sheets.

   ☐ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority. (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 0 sheets.

3. This report contains indications relating to the following items:

   I ☒ Basis of the report

   II ☐ Priority

   III ☐ Non-establishment of report with regard to novelty, inventive step or industrial applicability

   IV ☐ Lack of unity of invention

   V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

   VI ☐ Certain documents cited

   VII ☐ Certain defects in the international application

   VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
28 JULY 2000	26 MARCH 2001
Name and mailing address of the IPEA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer MATTHEW O. SAVAGE Jean Proctor Paralegal Specialist Telephone No. (703) 308-0661

Form PCT/IPEA/409 (cover sheet) (July 1998)★

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/US00/02071

I. Basis of the report

1. With regard to the elements of the international application:*

[X] the international application as originally filed

[X] the description:
pages 1-45, as originally filed
pages NONE, filed with the demand
pages NONE, filed with the letter of ____

[X] the claims:
pages 46-48, as originally filed
pages NONE, as amended (together with any statement) under Article 19
pages NONE, filed with the demand
pages NONE, filed with the letter of ____

[X] the drawings:
pages 1-11, as originally filed
pages NONE, filed with the demand
pages NONE, filed with the letter of ____

[X] the sequence listing part of the description:
pages NONE, as originally filed
pages NONE, filed with the demand
pages NONE, filed with the letter of ____

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language ____ which is:

[ ] the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).

[ ] the language of publication of the international application (under Rule 48.3(b)).

[ ] the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

[ ] contained in the international application in printed form.

[ ] filed together with the international application in computer readable form.

[ ] furnished subsequently to this Authority in written form.

[ ] furnished subsequently to this Authority in computer readable form.

[ ] The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

[ ] The statement that the information recorded in computer readable form is identical to the writen sequence listing has been furnished.

4. [X] The amendments have resulted in the cancellation of:

[X] the description, pages NONE

[X] the claims, Nos. NONE

[X] the drawings, sheets/~~fig~~ NONE

5. [ ] This report has been drawn as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).**

** Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*

*** Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.*

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/US00/02071

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. statement

Novelty (N)	Claims	NONE	YES
	Claims	1-7	NO
Inventive Step (IS)	Claims	NONE	YES
	Claims	1-7	NO
Industrial Applicability (IA)	Claims	1-7	YES
	Claims	NONE	NO

2. citations and explanations (Rule 70.7)

Claims 1-7 lack novelty under PCT Article 33(2)-33(3) as being anticipated by DE 4427354.

With respect to claim 1,'354 discloses a feed channel 17 (see FIG. 1) having a shear region including a length, no more than one permeate passage 20 associated with the shear region of the feed channel extending generally perpendicular to the direction of feed flow and having a width in the direction of feed flow less than the length of the shear region of the feed channel, and a porous medium 6 positioned between the shear region of the feed channel and the permeate passage.

With respect to claim 2, '354 discloses a feed channel 17 including a shear region (see FIG. 1), a plurality of permeate passages 20 associated with the shear region of the feed channel including first and second permeate passages 20a, 20b isolated from one another, and a porous medium 6 positioned between the shear region of the feed channel and the permeate passages.

With respect to claim 3, '354 discloses a feed channel 17 (see FIG. 1) including a shear region, a plurality of permeate passages 20 associated with the shear region of the feed channel, first and second flow/pressure control devices (e.g., defined by a cross section of passages 20) arranged to control permeate flow or pressure within at least one permeate passage independently of the flow or pressure within another permeate passage, and a porous medium 6 positioned between the shear region and the feed chamber and the permeate passages.

With respect to claim 4, '354 discloses a feed channel 17 (see FIG. 1) having a shear region, no more than one permeate passage 20 associated with the shear region, the permeate passage extending generally perpendicular to the direction of feed flow in the feed channel and having a width in the direction of feed flow on less than 20mm, and a porous medium 6 positioned between the shear region of the feed channel and the permeate passage.

With respect to claim 5, '354 discloses a process including generating a shear layer in a feed fluid PF (see FIG. 1), passing permeate from the shear layer into a first permeate passage 20a and passing permeate from the shear layer into a second permeate passage 20b isolated from the first permeate passage.

With respect to claim 6, '354 discloses the steps of (Continued on Supplemental Sheet.)

Supplemental Box
(To be used when the space in any of the preceding boxes is not sufficient)

Continuation of: Boxes I - VIII

V. 2. REASONED STATEMENTS - CITATIONS AND EXPLANATIONS (Continued):
generating a shear layer PF (see FIG. 1) in a feed fluid, passing permeate from the shear layer into first and second permeate passages 20a, 20b, controlling the permeate flow/pressure in the first and second permeate passages independently of one another by providing separate and distinct permeate passages each having a flow cross section.

With respect to claim 7, '354 discloses the steps of generating a shear layer PF (see FIG. 1) in a shear region at a porous medium 6, and independently controlling TMP incrementally along the length of the shear region by providing multiple permeate passages 20.

Claims 1-7 lack novelty under PCT Article 33(2) as being anticipated by DE 4342485.

With respect to claim 1,'485 discloses a feed channel 11 (see FIG. 2) having a shear region including a length, no more than one permeate passage 12 associated with the shear region of the feed channel extending generally perpendicular to the direction of feed flow and having a width in the direction of feed flow less than the length of the shear region of the feed channel, and a porous medium 9 positioned between the shear region of the feed channel and the permeate passage.

With respect to claim 2, '485 discloses a feed channel 11 (see FIG. 2) including a shear region, a plurality of permeate passages 12 associated with the shear region of the feed channel including first and second permeate passages isolated from one another, and a porous medium 9 positioned between the shear region of the feed channel and the permeate passages.

With respect to claim 3, '485 discloses a feed channel 11 (see FIG. 2) including a shear region, a plurality of permeate passages 12 associated with the shear region of the feed channel, first and second flow/pressure control devices (e.g., defined by a cross section of passages 12) arranged to control permeate flow or pressure within at least one permeate passage independently of the flow or pressure within another permeate passage, and a porous medium 9 positioned between the shear region and the feed chamber and the permeate passages.

With respect to claim 4, '485 discloses a feed channel 11 (see FIG. 2) having a shear region, no more than one permeate passage 11 associated with the shear region, the permeate passage extending generally perpendicular to the direction of feed flow in the feed channel and having a width in the direction of feed flow on less than 20 mm, and a porous medium 9 positioned between the shear region of the feed channel and the permeate passage.

With respect to claim 5, '485 discloses a process including generating a shear layer in a feed fluid PF (see FIG. 2), passing permeate from the shear layer into a first permeate passage 12 and passing permeate from the shear layer into a second permeate passage 12 isolated from the first permeate passage.

With respect to claim 6, '485 discloses the steps of generating a shear layer PF (see FIG. 2) in a feed fluid, passing permeate from the shear layer into first and second permeate passages 12, controlling the permeate flow/pressure in the first and second permeate passages independently of one another by providing separate and distinct permeate passages each having a flow cross section.

With respect to claim 7, '485 discloses the steps of generating a shear layer PF (see FIG. 2) in a shear region at a porous medium 9, and independently controlling TMP incrementally along the length of the shear region by providing multiple permeate passages 12.

Claims 1-7 lack novelty under PCT Article 33(2) as being anticipated by WO 96/01676.

With respect to claim 1,'676 discloses a feed channel (e.g., between the rotor 151 and filter element 148 shown in FIG. 2) having a shear region including a length, no more than one permeate passage 275 (see FIGS. 4A and 4B) associated with the shear region of the feed channel extending generally perpendicular to the direction of feed flow and having a width in the direction of feed flow less than the length of the shear region of the feed channel, and a porous medium 162 positioned between the shear region of the feed channel and the permeate passage.

With respect to claim 2, '676 discloses a feed channel e.g., between the rotor 151 and filter element 148 shown in FIG. 2) including a shear region, a plurality of permeate passages 275 (see FIGS. 4A and 4B) associated with the shear region of the feed channel including first and second permeate passages isolated from one another, and a porous medium 162 positioned between the shear region of the feed channel and the permeate passages.

With respect to claim 3, '676 discloses a feed channel e.g., between the rotor 151 and filter element 148 shown in FIG. 2) including a shear region, a plurality of permeate passages 275 (see FIGS. 4A and 4B) associated with the shear region of the feed channel, first and second flow/pressure control devices 251 arranged to control permeate flow or pressure within at least one permeate passage independently of the flow or pressure within another permeate passage, and a porous medium 162 positioned between the shear region and the feed chamber and the permeate passages.

With respect to claim 4, '676 discloses a feed channel e.g., between the rotor 151 and filter element 148 shown in FIG. 2) having a shear region, no more than one permeate passage 163 (see FIGS. 10A and 10B) associated with the shear region, the permeate passage extending generally perpendicular to the direction of feed flow in the feed channel and having a width in the direction of feed flow on less than 20 mm (see FIGS. 10A and 10B and lines 4-12 of page 24), and a porous medium 162 positioned between the shear region of the feed channel and the permeate passage.

With respect to claim 5, '676 discloses a process including generating a shear layer in a feed fluid (e.g., between the rotor 151 and filter element 148 shown in FIG. 2), passing permeate from the shear layer into a first permeate passage 275 (see

Supplemental Box
(To be used when the space in any of the preceding boxes is not sufficient)

Continuation of: Boxes I - VIII

FIGS. 4A and 4B) and passing permeate from the shear layer into a second permeate passage 275 isolated from the first permeate passage.

With respect to claim 6, '676 discloses the steps of generating a shear layer (e.g., between the rotor 151 and filter element 148 shown in FIG. 2) in a feed fluid, passing permeate from the shear layer into first and second permeate passages 275 (see FIGS. 4A and 4B), controlling the permeate flow/pressure in the first and second permeate passages independently of one another by providing, for example, means 251.

With respect to claim 7, '676 discloses the steps of generating a shear layer (e.g., between the rotor 151 and filter element 148 shown in FIG. 2) in a shear region at a porous medium 162 (see FIGS. 4A and 4B), and independently controlling TMP incrementally along the length of the shear region by providing, for example, means 251.

Claims 1-7 meet the criteria set out in PCT Article 33(4)because they recite devices and processes having an industrial use for filtering a fluid.

---------- NEW CITATIONS ----------

WO 96/0676 A (MILLER et al) 25 JANUARY 1996, see page 21, line 1, to page 23, line 21.

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

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PCT

NOTIFICATION OF TRANSMITTAL OF INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Rule 71.1)

Date of Mailing *(day/month/year)*	11 APR 2001
Applicant's or agent's file reference 440211/PALL	**IMPORTANT NOTIFICATION**

International application No.	International filing date *(day/month/year)*	Priority Date *(day/month/year)*
PCT/US00/02071	31 JANUARY 2000	29 JANUARY 1999

Applicant
PALL CORPORATION

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices)(Article 39(1))(see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

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